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The works of the Lord are great, sought out of all them that have pleasure therein.—Ps. cxi, 2.

THE SIDEREAL MESSENGER.

MAY, 1890.

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WM. W. PAYNE, EDITOR,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

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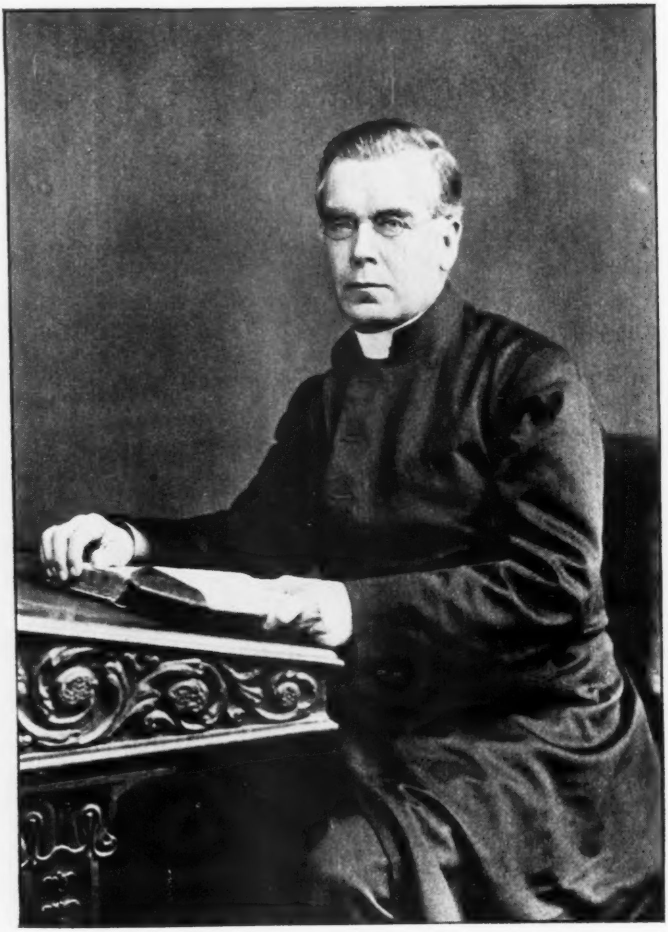

STEPHEN J. PERRY, S. J.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

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PHOTOGRAPHY AND MERIDIAN OBSERVATION.

TRUMAN HENRY SAFFORD.*

FOR THE MESSENGER.

The photographic chart of the heavens which is to be made, by about twenty associated observatories, will be accompanied by a set of plates of short exposure for catalogue purposes. The plates will be two degrees square, so that each one will contain on the average about twenty of the stars determined by the great zones now in progress; and this number will be more than sufficient in many cases. But there will be some plates for which additional stars will be needed around the edges. Consequently it may be necessary to observe a catalogue of about 20,000 stars in addition to the 200,000 of the great zones (if as is probable they are continued to the South pole); and to observe these 20,000 stars accurately meridian circles of the largest size must be employed. When the photographic chart is completed, it will be necessary to redetermine the stars of the great zones, especially in the northern hemisphere. The necessary accuracy will perhaps be greater than that of the zones themselves; the mean epoch of the latter is 1875, and that of the photographic chart will be about 1895.

Hence, if the great zones are repeated about 1905, with *twice* the accuracy of the original series, the positions for 1895 will be very advantageously obtained by interpolation.

This repetition of the great zones about 1905, that is to say, between 1900 and 1910, will be, also, I think, most readily done by photography. To accomplish this will require about 10,300 plates (2° square) for the whole heavens. With a photographic telescope of 13 inches aperture only

* Professor of Astronomy, Williams College, Mass.

one minute's exposure to each plate or, with one of 8 inches aperture certainly no more than three minutes' exposure will be required. Allowing as much for time employed in setting the telescope, we shall have six minutes observing time for an average of 15 stars. Or for the 5,000 plates of either hemisphere 500 hours photographic work; which can be readily accomplished in two years by two observatories.

After this has been done, it remains to measure the plate coordinates at leisure and convert them into right ascension and declination. In the complete survey of the heavens down to the 11th and 14th magnitudes, the plates will be regularly arranged. Near the equator each plate will begin 8 minutes farther on in right ascension than the preceding one; or at least some equally systematic order will be employed. But in making short exposures for 9th magnitude stars only it will be better to increase the number of plates by about 30 to 40 per cent, say to 7,000 for each hemisphere, so as to bring the brighter stars near the preceding and following edges, and thus use them for zero points. I have found by trial from the Durchmusterung that in almost all parts of the heavens the stars down to the 8th magnitude inclusive (8.4 or 8.5 of the D. M. scale), are sufficient in number and sufficiently well arranged to make this possible, provided they are very accurately determined.

The conclusion from this is that meridian observations of stars fainter than the 8th magnitude need only be made (for the next few years) for special problems like proper motion and for the zero-points of the great photographic chart; and that those down to the 8th magnitude only (8.4 or 8.5 D. M.) will be the proper work for meridian circles in future. Of such stars there are considerably more than 50,000 in the northern hemisphere; and they should be observed each four times before 1910. This, can easily be done by three meridian circles.

It would seem, then, that up to 1910 there is no very great need of so great masses of meridian observations as would have been required without photography. This latter art will relieve meridian observers of the most irksome part of their duties: the repetition over and over again of the same rather monotonous observations. The only real

problems of this kind for the future will be to keep the catalogues of stars to the eighth magnitude in proper order so as to have accurate places always available; and to observe fainter stars on the meridian only when they are especially interesting.

The comparison stars for comets and asteroids, will often be most readily determined by measuring them from a very few photographic plates along the course of the body,—unless, indeed, eighth magnitude stars are available,—and much time will be saved in the work of completely observing all the stars employed for any particular comet.

In other words, as the photographic process of cataloguing stars becomes more and more systematized many of the difficulties of meridian work will disappear. The zero-points of the plates which will be furnished by direct observation will be more regularly distributed in time; will not so often conflict with each other that the observer must wait years before he can finish his zone; and we shall have fewer star catalogues thirty or forty years in progress. But, on the other hand, the accuracy obtained on the small scale by photograph, an accuracy so great as to compete even with heliometer work, will require corresponding precision in the use of fixed instruments.

There are about one hundred complete sets of first class meridian instruments in active service; a number of these are in need of extensive repairs and reconstruction to make them adequate to the most accurate work.

The subject of systematic differences between results needs especial study at this time; it is hardly worth while to go on repeating observations which have been lately made elsewhere without such study.

And the probable error of the single observation should not now exceed half a second of arc of a great circle in either co-ordinate; nor should any first rate observer be content (for example) with a series of declinations in which discrepancies of 2″ from the mean of 8 or 10 are at all common.

With regard to the plans of future meridian work I have thought a good deal; chiefly for my own purposes. The stars of the 6th magnitude and brighter need now to be observed only for zero-points and for comparisons; otherwise they need discussion of all available materials rather than

re-observation. The Greenwich ten-year catalogue just out contains a great many of them, and the lacking ones are now on the Greenwich working list. The stars of the 7th magnitude are very frequently used, for a variety of purposes, both with small instruments and large; a 3-inch transit is large enough for the *accurate* observation of a star of the magnitude 7.4 and a 2-inch for one $6^{m}.5$. In fact the best stars for a 2½-inch transit—the size most commonly used in longitude and latitude work—are precisely those brighter 6th and higher 7th magnitudes whose exact places are hardest to find in the catalogues.

Any meridian observer who wishes to avoid throwing away his labor can be very sure to do a good thing by observing 7th magnitude stars in some definite region with great accuracy; four observations to each object are usually sufficient.

These stars are now of some importance because they are in many cases well determined at an early date. Bradley has few of them; but D'Agelet, Fedorenko, Piazzi, Lalande or Groombridge a great many. Those of the 8th magnitude will especially be needed after 1900.

It will be seen from what I have said in this rather desultory way that photography will practically limit the great mass of future meridian observations (after the plans now in progress are executed) to stars of the eighth magnitude and brighter; that observers should in future confine themselves to making thoroughly good observations, strictly differential in character, unless they are working intelligently upon the fundamental catalogues; that in all probability a good many of the older instruments will be quietly hung up and disused; but that the best and most modern circles (like those of Repsold) will long aid in the solution of important problems. I must reserve for another opportunity the reference to a number of special problems now ripening for solution; but should be glad to correspond with any younger observer who is anxious to make the best of his opportunities in this direction.

STEPHEN J. PERRY, S. J.

C. M. CHARROPPIN, S. J.*

For The Messenger.

Stephen Joseph Perry was born in London on August 26, 1833, and received his preparatory education at Gifford Hall School. Early in life he went successively to Douay and Rome to complete his higher studies. Believing himself called by his Creator to work for the salvation of souls, he determined to study for the priesthood. The principal trait of his character was his devotedness to duty, and a remarkable spirit of self-sacrifice which endeared him to all those who knew him. This spirit of self abnegation, this total forgetfulness of self, in order to be useful to his fellow beings, constituted the basis of his many other virtues. One of his familiar mottoes was, "Whatever you do, do it well," and he often repeated: "That a man should throw himself heart and soul into the occupation of the hour." Hence it was that he showed the same earnestness when engaged in a game of foot-ball with the boys of Stonyhurst, as when solving some difficult problem of Solar Physics. He seemed to take as much interest in the conversation of the little boys of the preparatory school, as in the society of the scientific celebrities of the age. His whole character may be summed up in a few words; a learned Jesuit, a great astronomer, yet as simple as a child—one devoted to the duties of his profession and ready to sacrifice his life for the promotion of science.

When scarcely eighteen years of age he studied the institute and constitutions of Ignatius of Loyola. The military plan of the hero of Pampaluna, captivated the mind of the young aspirant, and on the 12th of November, 1853, he entered the novitiate of Stonyhurst, England. After two years' novitiate he went to France for a course of literature, and, after a year, returned to England to complete his philosophy. His superiors soon discovered his great aptitude for Mathematics and his fondness for the most sublime of sciences, Astronomy. He attended the lectures of De Morgan, and in 1858 he occupied the sixth place on the mathematical honors' list of the London University. Soon after

* Professor of Astronomy in the St. Louis University, St. Louis, Mo.

he was sent to Paris for a full course of the higher mathematics. On returning to Stonyhurst in 1862 he was appointed professor of mathematics; after so thorough a training he was found well qualified to take charge of the Observatory.

In September, 1863, he went to study Theology at St. Beuno's College, North Wales, and in 1866 he was ordained priest. Two years later he returned to Stonyhurst, to resume his professorship and to take charge of the Observatory. From this time he never left the college save to take part in some scientific expedition.

In 1866 the Stonhyurst Observatory was selected by the government as one of the principal meteorological stations. Up to that date, the Observatory had been engaged chiefly in meteorological and magnetic observations. In 1874 the Government presented to Fr. Perry a large direct-vision spectroscope made by Browning. Two years later a fine McLean spectroscope was presented by the Meteorological Society. With these two fine instruments Fr. Perry devoted most of his time to the study of Solar Physics.

In addition to this work, regular observations of Jupiter's satellites were made, together with many observations of the spectra of stars. Fr. Perry was a popular lecturer. The people of Liverpool, Wigan, and the neighboring towns will long remember his impressive and interesting lectures, discoursing with ease and earnestness on astronomical topics.

Fr. Perry's labors were not confined to the Observatory alone. In 1868, accompanied by Fr. Sidegreaves, he made a magnetic survey of the west of France. He spent his vacation, the following year, in a like survey of the east of France. Similar surveys occupied his time in Belgium in 1871, in Kerguelen in 1874 and in Nos Vey, Madagascar, in 1882. It was principally on account of his magnetic surveys that Fr. Perry was made Fellow of the Royal Society, on June 4, 1874. Later on he was elected a member of the Council.

In 1870 he took part, for the first time, in an eclipse expedition, his station being Cadiz. In 1874 he was selected by Sir George Airy, Astronomer Royal, as chief of the party destined to observe the transit of Venus at Kerguelen. With

great constancy and energy he overcame many obstacles thrown in his way. The following sentence quoted from his journal was no empty boast: "We were determined that no consideration should make us flinch where the astronomical interests of the expedition were at stake." In 1882 he went to Madagascar for the last transit of Venus. For the eclipse of Aug. 29, 1886, he went to Curacoa in the West Indies; for that of Aug. 19, 1887, to Russia, and last November he sailed for the Islands of Salut, where he observed successfully the eclipse of Dec. 22, 1889, five days before his death.

In an article of limited space it would be impossible to mention, even in a cursory way, all the work undertaken and accomplished by this energetic astronomer. His notes on Jupiter and the red spot, his spectroscopic observations of comets, stars and auroras; his measurement of the chromosphere of the sun, his many papers on solar protuberances and notes on the occultation of stars by the moon, form an immense amount of material, which when thoroughly worked out, will, doubtless, yield very important results.

His labors were appreciated by men of science, and the different learned societies vied with each other to obtain his consent to become an active member of their organizations. As already mentioned he was a Fellow and Member of the Council of the Royal Society; also of the Royal Astronomical Society, and a member of the Royal Meteorological Society, the Physical Society of London, and the President of the Liverpool Astronomical Society. In 1886 he received the honorary degree of Doctor of Science from the Royal University of Ireland, and at various dates he was elected a member of the Accademia del Nuovo Lincei, la Société Scientifique de Bruxelles and la Société Geographique d'Anvers. For several years preceding his death he served on the committee of Solar Physics appointed by the Lords of the Committee of Council on Education; also on the committee for comparing and reducing magnetic observations, appointed by the British Association for the Advancement of Science. He came to America in 1884, on his way to attend the meeting of the British Association held in Canada. Those who met him at Woodstock, Maryland, were favorably impressed

with his genial conversation and unassumed simplicity. In April, 1887, he took part in the International Astrophotography Congress held at Paris.

His last expedition was to the Islands of Salut to observe the eclipse of the 22d of December, 1889. Though attacked by mortal sickness and feeling very ill, he stood at his post on that memorable day, giving quietly his orders and taking, himself, charge of the principal instrument. This was his last work on earth. He was carried to the Comus, and as he saw his last end approaching he gave his instructions to his assistant, Mr. Rooney, S. J., and requested Captain Atchinson to set sail for Demerara, hoping to die among his brethren at Georgetown; but he gave up his soul to his Creator before reaching Demerara, on the 27th of December, 1889. The bishop of the place, the commandant with many attendants, came in a tug-boat to meet the Comus. Fr. Perry had promised the bishop to lecture on the eclipse, on his return. Great then was their grief and disappointment on learning the sad reality. They received into the tug-boat the remains of the illustrious astronomer, and his funeral took place the following day. Fr. Perry died a true martyr of science and the astronomical world will long feel his loss.

A SHORT METHOD OF FORMING THE EQUATION IN CARTESIAN COORDINATES OF AN ELLIPSE PASSING THROUGH FIVE POINTS.

H. H. FURNESS, JR.

For THE MESSENGER.

In answer to the query in THE SIDEREAL MESSENGER for February: "What is the equation in Cartesian co-ordinates of an ellipse passing through five points $x_1\, y_1$; $x_2\, y_2$; $x_3\, y_3$; $x_4\, y_4$; $x_5\, y_5$, or the simplest manner of forming it?" I beg to offer the following solution:—

If α, β, γ, δ, represent the equations of the sides of a quadrilateral, then

$$\alpha\gamma + k(\beta\delta) = 0$$

is the equation of any conic passing through the four vertices and one other point dependent on the value of k.

Let me now illustrate by means of an example the method of determining this value k:

For instance let it be required to find the equation of a line passing through the point 2, 3 and the intersection of $x - 3y + 2 = 0$ with $3x + y - 7 = 0$

Then $x - 3y + 2 + k\,(3x + y - 7) = 0$ is the equation, and since this is to pass through the point 2, 3, these values viz., $x = 2$, $y = 3$ must satisfy it. Thus:

$$(2 - 9 + 2) + k\,(6 + 3 - 7) = 0$$
$$-5 + 2k = 0$$
$$k = \frac{5}{2}$$

Then, substituting this value of k in the equation above, we obtain

$$x - 3y + 2 + \frac{5}{2}\,(3x + y - 7) = 0$$

or clearing of fractions and reducing we get

$$17x - y - 31 = 0$$

which is the equation of the line required.

This is precisely the method we shall employ in the following calculation:

The formula for forming the equation of a straight line passing through two points x', y', and x'', y'', is

$$y - y' = \frac{y' - y''}{x' - x''}\,(x - x')$$

Employing this formula for determining the equations of the sides of the quadrilateral, mentioned above, its vertices being $x_1\,y_1$; $x_2\,y_2$; $x_3\,y_3$; $x_4\,y_4$; we obtain

$$y - y_1 = \frac{y_1 - y_2}{x_1 - x_2}\,(x - x_1)$$

or: $\dfrac{y - y_1}{y_1 - y_2} - \dfrac{x - x_1}{x_1 - x_2} = 0$ for the side α

$\dfrac{y - y_3}{y_3 - y_4} - \dfrac{x - x_3}{x_3 - x_4} = 0$ for the side γ

Then $\alpha\gamma = \left\{\dfrac{y - y_1}{y_1 - y_2} - \dfrac{x - x_1}{x_1 - x_2}\right\}\left\{\dfrac{y - y_3}{y_3 - y_4} - \dfrac{x - x_3}{x_3 - x_4}\right\}$

Again:

$\dfrac{y - y_2}{y_2 - y_3} - \dfrac{x - x_2}{x_2 - x_3} = 0$ for the side β

$\dfrac{y - y_4}{y_4 - y_1} - \dfrac{x - x_4}{x_4 - x_1} = 0$ for the side δ

Then:

$$\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}=\beta\delta$$

And $\alpha\gamma+k\,(\beta\delta)$ will be:

$$\left\{\frac{y-y_1}{y_1-y_2}-\frac{x-x_1}{x_1-x_2}\right\}\left\{\frac{y-y_3}{y_3-y_4}-\frac{x-x_3}{x_3-x_4}\right\}$$

$$+k\left[\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}\right]=0$$

And this is the equation of a conic passing through these four points and one other dependent on the value of k.

Now since the conic is also to pass through $x_5\ y_5$ we have (when these values for x and y are substituted in the value of k, found from the last equation by transferring the first term over to the other side and dividing by the coefficient of k) the following:

$$k=\frac{\left\{\frac{y_5-y_1}{y_1-y_2}-\frac{x_5-x_1}{x_1-x_2}\right\}\left\{\frac{y_5-y_3}{y_3-y_4}-\frac{x_5-x_3}{x_3-x_4}\right\}}{\left\{\frac{y_5-y_2}{y_2-y_3}-\frac{x_5-x_2}{x_2-x_3}\right\}\left\{\frac{y_5-y_4}{y_4-y_1}-\frac{x_5-x_4}{x_4-x_1}\right\}}$$

Then substituting this value of k in $\alpha\gamma+k\,(\beta\delta)=0$ we obtain for our last result (after clearing of fractions) the following equation:

$$\left\{\frac{y-y_1}{y_1-y_2}-\frac{x-x_1}{x_1-x_2}\right\}\left\{\frac{y-y_3}{y_3-y_4}-\frac{x-x_3}{x_3-x_4}\right\}$$

$$\times\left\{\frac{y_5-y_2}{y_2-y_3}-\frac{x_5-x_2}{x_2-x_3}\right\}\left\{\frac{y_5-y_4}{y_4-y_1}-\frac{x_5-x_4}{x_4-x_1}\right\}$$

$$-\left\{\frac{y-y_2}{y_2-y_3}-\frac{x-x_2}{x_2-x_3}\right\}\left\{\frac{y-y_4}{y_4-y_1}-\frac{x-x_4}{x_4-x_1}\right\}$$

$$\times\left\{\frac{y_5-y_1}{y_1-y_2}-\frac{x_5-x_1}{x_1-x_2}\right\}\left\{\frac{y_5-y_3}{y_3-y_4}-\frac{x_5-x_3}{x_3-x_4}\right\}=0$$

I fear the querist will scarcely feel that I have helped him by presenting such a formidable equation as the simplest, yet such it is.

My thanks are due in great part to Professor E. S. Crawley, of the University of Pennsylvania, for his efficient help and kind supervision of the work.

SUGGESTIONS AS TO A NEW GENERAL CATALOGUE OF STARS.

G. F. CHAMBERS, F. R. A. S.

I have recently been engaged in compiling for my own purpose a catalogue of all the naked-eye stars down to the 5th magnitude, basing my magnitudes in all cases on the Harvard Photometry, the Uranometria Oxoniensis, or the Uranometria Argentina as the case might be. Two points have very forcibly impressed themselves upon me in executing this task: (1) The urgent necessity which exists that astronomers should be provided as soon as may be with a new comprehensive general catalogue of stars; and (2) that the photometric methods put in practice at Harvard and Oxford ought to be applied with the least possible delay to the southern hemisphere.

By a comprehensive general catalogue I mean one modeled in some degree on the B. A. C., but to contain many more stars, or, say all stars down to the seventh magnitude. I believe it is the fashion in some quarters to sneer at the B. A. C., but most unreasonably, as I venture to think. Of course it is forty-five years out of date; of course it is not up to the requirements of the present generation: new methods, and new instruments (and many more of them), are now to be found which were not available when Baily performed his self-allotted task. All these things support my plea for a new catalogue.

The Royal Astronomical Society of London when an infant institution did useful service by publishing a general catalogue of its own: that work paved the way for the B. A. C., and my present suggestion is that the society or its German brother, the Astronomische Gesellschaft, should take in hand forthwith the new general catalogue which is so much wanted. I will make no attempt at this moment to suggest how it should be put together.

With reference to the question of photometric methods, I have been much struck in putting together my catalogue (in which I have given both sets of values) with the remarkable accord everywhere subsisting between the Harvard and Oxford values. This uniform accord seems to me to render the intrinsic value of both very high indeed. And it is this

belief which induces me to urge very strongly the desirability of the whole southern hemisphere being investigated at once with instruments of the like character. This idea; undoubtedly sound in the abstract, finds confirmation in the discrepancies which I have noticed in the magnitudes assigned by Dr. Gould in the Uranometria Argentina to the stars below (say) mag. 5½ which were observed for magnitude by him, as well as at Harvard and Oxford, and I think that the sooner the stars in the southern hemisphere are submitted to exact photometric test by means of suitable photometric instruments the better.—*Astronomische Nachrichten*, No. 2952.

EAST BOURNE, SUSSEX, ENGLAND.

THE REFINEMENT OF MODERN MEASUREMENTS.*

BY J. A. BRASHEAR.

Progress is to-day written upon every page of the world's record; and particularly in the realms of science is it making its unmistakable mark; from thence extending outward to the vast range of correlated studies that go to make up the sum of human knowledge and economics. In astronomy and astronomical engineering, in physics and chemistry, in civil and mineral engineering, in meteorology and in metrology and in mechanics, to say nothing of many other branches of science, do we find progress as the watchword and the theme that excites and moves the human brain to grander and better achievements. It is my pleasure, and an enjoyable privilege, to call the attention of this Society, in my retiring address as your president, to some of these lines of progress in which I have for many years been interested, and which I trust will prove of interest to you. I shall therefore present some thoughts on the refinements of modern measurements.

When Dr. Alfred M. Mayer, of the Stevens Institute, published his splendid papers on the minute measurements of modern science in the *Scientific American* Supplement, some fifteen years ago, it opened the eyes of many of our Ameri-

*From the Transactions of the Engineers' Society of Western Pennsylvania.

can mechanics to the possibilities of a refinement in measurements they had never dreamed of, and I believe those papers, written in such clear and untechnical language, have done an incalculable amount of good to mechanics, who today show it by their accurate work, to some of which I shall refer later on.

The day has forever passed when we are willing to say or believe that "three barley-corns make one inch," nor is the advanced mechanic of to-day satisfied with his boxwood rule, graduated to thirty-seconds of an inch, save for the coarsest approximate measurements; but he must have his Brown and Sharp standard graduated to one one-hundredth inches for his *coarse* measures, and his micrometer gauges reading to one one-thousandth for his ordinary work. Even in our iron and steel works, the old-time wire guage, that for a long time held its own, has been displaced by the modern micrometer guage of infinitely greater accuracy.

My esteemed friend, Mr. George M. Bond, has said very appropriately, that "the arm of King Henry the First, or the barley-corn, though possibly furnishing standards good enough for that time, would hardly satisfy the demands of our modern mechanics or tool-makers, who work very often within the limit of one-thousandth of an inch, and even one-tenth of this apparently minute quantity, with surprising unconcern and no less accuracy." Prof. Wm. A. Rogers has also shown that many of our modern mechanics can calliper to one thirty-thousandth of an inch. These, however, are coarse, rough measures when compared with others I shall mention in the course of this paper.

In the domain of astronomical measurements great progress has been made of late years by the use of refined instrumental means, as well as the many methods devised for the elimination of instrumental errors. The divisions of the meridian circle have been brought to astonishing accuracy. I may mention two of the best dividing engines in the world which I have examined through the courtesy of the constructors. Perhaps the most celebrated is that of the Repsolds in Hamburg. This wonderful engine has come through three generations of celebrated mechanicians, each one adding to its accuracy until now it seems to have

reached the limit of human capability; in other words, as perfect as the environments of temperature, and other factors over which human hands and brains have no control, will allow it to be brought. The maximum error of the best circles divided by this engine equals 1.17″. This engine is not automatic, but each line is set by from one to five microscopes, and the division traced by hand.

The other engine is that constructed by Messrs. Fauth & Co., of Washington, D. C., and is entirely automatic in its work. It is a fine piece of mechanical construction, and does honor to the constructors, and when compared with the original dividing engine of Ramsden, which I have examined, and which was a marvellous piece of work for its time, it tells unmistakably the advance of modern mechanical appliances in that direction. The mean error of a circle recently divided on this engine for the Cincinnati Observatory, as determined by Prof. Porter, is not greater than 1.0″. The Heliometer is now playing a most important part in accurate astronomical measurements, and the work of Dr. Elkin of the Yale University Observatory, and that of Dr. Gill at the Cape of Good Hope, with this instrument, will, in all probability, give us a nearer approach to the absolute solar parallax than has yet been obtained; and this may be appreciated when you remember that the uncertainty lies in the third decimal place of seconds of arc, a quantity altogether inappreciable to ordinary mortals.

This instrument has been largely used in a determination of the parallax of the "fixed" stars, and such measurements are perhaps the most refined in the whole realm of astronomical studies, as no star has yet been found with a parallax greater than 0.9 seconds of arc, and most of those nearest to us are not greater than half that quantity. When it is considered that personal and instrumental errors must be eliminated for a period extending over one-half the earth's annual revolution, it is not to be wondered that in many cases the measure came out sometimes a plus—sometimes a minus quantity, with instruments used for the purpose before the Heliometer was brought into requisition. I should like to describe this instrument, which indeed has been wrongly named, but time will not permit.

The astronomical camera is also adding largely to accur-

ate astronomical measurements. It was thought at first that the shrinking of the film on the negatives would make stellar distances an uncertain factor, but no less an authority than Dr. Elkin asserts that the photographic charts of the Pleiades are as accurate for refined measurements as the stars themselves by the use of the Heliometer, and whereas many of these stellar measurements have to be carried on for years under the most trying conditions, by the photographic method, a few hours will photograph all the stars of a group, or cluster, down to the sixteenth magnitude, and then the plate may be leisurely studied and measured in the laboratory without hindrance from cloud, bad definition or the thousand and one difficulties the astronomer meets in endeavoring to reach his ideal. I could dwell here for all the time at my disposal, but I dare not.

Time measurements in astronomical Observatories have reached wonderful accuracy. When our big bell tolls the quarert hours of the dial, we pull out our watches and are satisfied if we are within quarter of a minute. Fortunately, our astronomer at the Allegheny Observatory is not so easily satisfied. If the stars will but shine, he is not content if the error be sixty times less, *i. e.*—a quarter of a second; and I recently saw the figures for several days' "time" work, where the errors were not greater than three one-hundredths of a second. We all know the great benefit of this time, transmitted to our railroad centers, and if human ingenuity could but have the trains keep time with the stars, we should never have the paradoxical phenomenon of two trains endeavoring to occupy the same track at the same time.

A recent instrument for accurate astronomical measurement, invented by Prof. S. P. Langley, and constructed at our works, is named by the inventor an occulting eye piece. Experiments have shown that the time of the occultation of a star may be readily determined with this instrument within one-twentieth of a second, and with experience the time may possibly be determined within one-fiftieth of a second, and this perfectly free from the element of personal equation.

In the construction of astronomical instruments greater and greater perfection is being reached in every decade, and

the time has passed when the astronomical engineer is satisfied with "cut and try" methods as of old. The mathematician stands by him ever ready with the magic plus and minus, to urge him on to higher attainments, to reach as near as possible to the demands of nature's unalterable laws. The object-glass of the telescope, that marvellous eye that peers into the fathomless depths of stellar space, is now brought to most wonderful perfection, and has almost reached the limit of human possibilities. The refinement of the measurements of its curves may be slightly comprehended by the uninitiated, when I say from personal knowledge and experience that the rubbing of a surface for a few seconds of time with the tip of the finger and the finest of polishing material, may ruin the accurate performance of the glass. The measurements of the curves sometimes reach to the sixth decimal place, and the artist of to-day can determine so minute a quantity with great precision and certainty. In modern investigations of the object-glass of the telescope, no one has done so much to bring it up to the highest standard of perfection as Dr. Charles S. Hastings of Yale University. He has just completed some of the most refined studies in this line that have ever been made, and, perhaps, since the days of Gauss, no such advancement in mathematical dioptrics has been made, which, carried out experimentally, is now yielding most remarkable results.

In the realms of physical investigation and apparatus, great accuracy has been reached in the past few years. Let me mention one branch in which I have taken an humble part, namely, the production of optical surfaces and the ruling thereon of those marvellous diffraction gratings which have so greatly advanced the study of spectrum analysis. I can well remember when Nobert, of Pomerania, produced his first test-bands for the microscope, and when he produced his first diffraction grating, which in its entire ruled surface, was but two centimeters square. To-day we are producing surfaces fifteen centimeters square, in which the error of curvature or flatness, as the case may be, is less than one two-hundred-thousandths of an inch; and on which Prof. Rowland has ruled one hundred and ten thousand lines with such precision that the error between any two of the lines is probably less than one three-millionths of

an inch. With this instrument of research physicists have boldly entered into new and untrodden regions of nature, and are from time to time uncovering her hidden wealth to enrich the storehouse of earthly knowledge. I present for your inspection the wonderful map of the spectrum of the sun, which has been so recently placed in our possession by Professor Rowland. Here, spread before you, is the result produced by the use of the concave diffraction grating, untouched by the hand of man. Here, in the red end of the spectrum, you see the marvellous B group, never before photographed as you see it now. Here you see the great C line and here the D lines, one of which is plainly double, while you see thirteen lines between the D lines. I can well remember when the instrument that would show the one nickel line between the D lines was considered a marvellous piece of work. Passing over the thousands upon thousands of lines between the D lines and the H line, we stop for a moment to examine between the H and K lines. Here is Angstrom's celebrated map of the solar spectrum. If you will examine it you will see he places three lines between H and K. In this photographic chart before you, I count one hundred and twenty-one lines between the H and K. But here Angstrom stops with his chart, because the human eye fails to see satisfactorily much farther; but on this photographic chart we have, beyond the H K group, more lines than in the whole of Angstrom's map, as you see extending about thirteen feet on the photographic chart beyond that which is visible to the human eye, and containing thousands of lines. The value in wave lengths on these charts is given within one one-hundred-thousandth of its true position.

All this has been brought about by work of the highest character requiring refined measurements and manipulation, of which our forefathers knew practically nothing. But the end is not yet. Refined as these measures may be, yet finer and more critical are being done, and we are now constructing a machine called by its inventor, Professor Albert Michaelson, an "Interferential Refractometer," in which this same phenomena of interference is made the basis of measurement which lies close to the border land of human possibilities.

You are all aware that the various enlightened and civilized nations have standards of weight and measure that

have slowly been evolved from the cubit, the span, the finger length and the barleycorn, if you please. Intimately associated with the evolution of standards of measurements are the names of Kater, Bailey, Bessel, Airy, Bird, Troughton, Babbage, Ramsden, Repsold and many others I could name; but in our modern work perhaps few men have done more than our own Professor William A. Rogers, whom some of you know personally. I here submit to you one of his decimetre standards in which we have included standards for the centimetre, millimetre and hundredths of millimeters.

But, as I said, nations have their standards. On what are they based? The French metre is presumed to be one ten-millionth of the earth's quadrant, the English yard evolved from the barley-corn, etc., but the measurements of precision in our day demand an indestructable, absolute and unalterable basis for our standards, so that if they all be destroyed the original is still available. Professor Michaelson has chosen a wave-length of sodium light as the basis for a new standard, a something that will remain forever of the same absolute linear value, or at least so long as the solar system floats in the luminiferous ether that, so far as we know, pervades the entire universe. Now, a wave-length of sodium light is, roughly speaking, about one forty-two-thousandths of an inch long; or better, five thousand eight hundred and ninety ten-millionths of a millimeter. Now, as this is an appreciable figure, it is evident that any method proposed to measure its *absolute* value must be of the highest accuracy. The method devised by Professor Michaelson in the refractometre has certainly brought the work to marvellous perfection; for in a paper read by him at the Cleveland meeting of the American Association, he showed that the error was not greater than one part in two millions, and possibly would be made not greater than one in ten millions. Gentlemen, can you appreciate such a quantity? Yet here is a physicist, with a high ideal of perfection, taking the pulsations that are sent earthward by the sun, and by methods within the reach of human skill, actually recording them upon a standard bar immersed in a freezing mixture and giving us a universal standard based upon the absolute value of a wave-length of light. You may appreciate some of the niceties in the construction of this interferential re-

fractometer when I tell you that in making some of the optical surfaces for use with it, Professor Michaelson demands an accuracy closely bordering on one millionth of an inch.

With the new instrument Professor Michaelson proposes to carry out advanced experiments on studying the coefficients of expansion of standards, etc., the coefficients of elasticity, and critical measurements of the indices of refraction of various substances. But I must not dwell here, though the theme is as enchanting as Fairy Land. Nations have joined together for the production of standards of weights and measures, and but recently our government has received its new set, of which I hope we shall have a full description in the lecture we are to enjoy from Professor Mendenhall on this very subject. It may be of interest to you, however, to mention the fact that Professor Wm. A. Rogers, formerly of Harvard Observatory, has devoted the better part of his life in studying the errors of standards in use in this country and in Europe, as well as producing some of the best work in this line that has ever yet been done. Perhaps no living man has worked so earnestly upon his hobby. For years he got out of his bed at five o'clock every morning to compare his bars of bronze, steel, copper and glass, at an hour when they had swung through their occillation or temperature changes so as to be able to determine the absolute value of their coefficient of expansion, as well as to learn whether the material from which the standards were made passed through slow molecular changes or not. Among many important facts he has brought to light, is that of the equable expansion of metals, etc., *i. e.*, that the expansion is equal for each degree within a range from zero to the boiling point, so that it is now only necessary to know the coefficient for one degree, and add or subtract from the standard temperature at which the bar was normal. In the production and ruling of these standards there are so many factors that come as hindrances to perfect work, that Professor Rogers must have added to his virtues that of patience to a very large degree. I have no doubt some of our members call to mind his paper, read in Pittsburgh some four or five years ago, before the National Association of Mechanical Engineers, on "A Solution of the Perfect Screw Problem." The great Whitworth said, "a perfect screw was never

made," and perhaps he was correct, but Professor Rogers has brought its solution about as close as any living man, except, perhaps, Professor Rowland, who indeed makes the best screw possible by mechanical means, and then by studying its errors, eliminates them by one of the most simple, yet beautiful devices, ever applied to the solution of so important a problem. Those of you who may be interested in this matter, will find a most excellent article on the subject by Professor Rowland under the title, "Screw," in the ninth edition of the *Encyclopædia Britannica*. I here take the liberty to show you a screw made under the supervision of Professor Rogers in some of his earlier work. Its linear error is not greater than 0.00005 of an inch, but it has unfortunately a periodic error of drunkenness, that makes it useless for the purpose for which it was designed, though for purposes where it can be used in whole revolutions, it is perhaps equal to any ever made. It cost the labor of two of the best workmen of the Waltham Watch Tool Co., for 425 hours, at $1 per hour, so that it cost almost half its weight in gold.

One of the most delicate methods of studying a so-called perfect screw is to rule a diffraction grating by the aid of a diamond moved by the screw. If there are errors of drunkenness as in this screw, the interference is so irregular that no lines can be seen in the spectrum of the line from the grating so ruled. If it is more nearly perfect, the imperfection is made known by false lines or ghosts in the spectrum, and like Banquo's, they will not down until the errors of the screw are eliminated. There are many other methods of determining errors in the run of a screw, some of them of high value, and it is with considerable pride that I say our American machine shops are taking advantage of them to produce better and better work.

(TO BE CONTINUED.)

ASTRONOMICAL SOCIETY OF THE PACIFIC.
MARCH, 29, 1890.

By invitation the Annual Meeting was held in the rooms of the California Academy of Sciences, the President, E. S. Holden, presiding.

The minutes of the last meeting were read and approved. After thanking the Academy of Sciences for the use of their large rooms the chair called upon the Committee on Nominations to report. The Committee submitted the following ticket of eleven for Board of Directors and a Committee of three on Publication:

For Board of Directors—E. S. Holden, Frank Soule, J. M. Schaeberle, Charles Burckhalter, Wm. Alvord, Wm. M. Pierson, E. J. Molera, C. M. Grant, C. B. Hill, J. H. Wythe, F. R. Ziel.

For Publication Committee—E. S. Holden, J. E. Keeler, C. G. Yale.

The polls were declared open until 9 o'clock and Messrs. E. H. McConnell and F. R. Ziel appointed tellers. The election resulted in the ticket being unanimously elected.

The following were elected to membership: Messrs. Grieg, Maw and Davidson, were made life members; Alanson H. Phelps, H. C. Lion, H. T. Bestor, A. M. Hickox, Harvey Durbrow, Mrs. H. A. Harland and W. E. Hess, San Francisco; George Gleason, Berkeley, Cal.; Miss M. E. Chase, Santa Rosa, Cal.; A. W. Craig, Oakland, Cal.; Mrs. Harriet Wright, Denver, Colorado; D. Patin, Philadelphia; J. J. Malowney, Hebron, Neb.; Arthur M. Hussey, Ann Arbor, Mich.; Andrew Greig, Tay Port, Scotland; Miss Dorothea Klumpke, Paris, France; O. A. H. Pihl, Christiania, Norway; A. Stanley Williams, F. R. A. S., Brighton, England; W. H. Maw, F. R. A. S., London, England; Herbert Sadler, F. R. A. S., London, England; John Tebbutt, F. R. A. S., New South Wales; J. Ewell Davidson, Queensland, Australia; Miss Lassell, Maidenhead, England.

The Secretaries announced the receipt of seventy-five presents and publications and the thanks of the Society were returned to the donors.

Treasurer E. J. Molera read his Annual Report which showed the following results for the first year's work of the Society.

Receipts from Dues	$2,145.00
Receipts from Publications	2.00
Received from Alexander Montgomery for Library Fund	2,500.00
Received from Joseph A. Donohoe for Comet Medal Fund	500.00
Total Receipts	$5,147.00

Expenditures for Publications and other expenses	$1,026.25
Cash in Bank (General Fund)	1,120.75
Cash in Savings bank	3,000.00

$1,000 of the Library Fund is to be expended in the purchase of a library for the use of the members.

A communication was read from Messrs. Hausman and Jones, proposing the establishing of an Observatory in San Francisco for the use of members of the Society. The communication was referred to a committee to report at the next meeting.

Mr. J. M. Schaeberle presented a paper entitled "A Mechanical Theory of the Solar Corona." It stated that his investigations seemed to prove conclusively that the solar corona is caused by light emitted and reflected from streams of matter ejected from the sun by forces which in general act along lines normal to the surface of the sun; these forces are most active near the center of each sun-spot zone.

Owing to the rotation of the sun, the streams of matter will not lie along normals, since the angular velocity of different portions of the stream grows less as the distance from the sun increases; in other words, the streams are double curvature. Each individual particle of the stream, however, describes a portion of a conic section, which is a very elongated ellipse so long as the initial velocity is less than 383 miles per second (assuming that the sun's atmosphere, as shown by various observations, is exceedingly rare).

The variations in the type of the corona admit of an exceedingly simple explanation, being due to nothing more than the change in the position of the observer with reference to the plane of the sun's equator. Accordingly, as the observer is above, below, or in the plane of the sun's equator, the perspective overlapping and interlacing of the two sets of streamers cause the observed apparent variations in the type of the corona.

Mr. Schaeberle then exhibited a model, in which the sun is represented by a ball about an inch in diameter, from which radiate a number of needles, to represent the streams of matter. All these needles are contained between two zones corresponding to $\pm 30^\circ$ of latitude. The longer ones are most numerous near the middle of each zone, and slightly more inclined to the normal than the shorter ones, in order

that the more distant portions of the needles (representing the outgoing streams) shall have directions roughly the same as required by physical laws. Eight photographs of the model, representing the various types of the corona, were also shown.

When the model is placed in a beam of parallel rays and its shadow allowed to fall upon a screen, the slightest change in the position of the model produces an entirely new image.

Mr. Schaeberle stated that he had thus far been unable to find a single observed phenomenon which could not be accounted for by this mechanical theory.

A discussion of the theory and a comparison showing the remarkable agreement with observation will appear in the report of the eclipse of December 21, 1889.

Mr. Holden gave an account of the photometric determinations of the actinic brightness of the Corona. Two of the plates taken by Mr. Burnham and two taken by Mr. Schaeberle were standardized. A preliminary reduction of these plates show that the brightness of the corona and sky, as measured directly from the plates, will substantially reproduce the results obtained by Mr. W. H. Pickering at the eclipse of 1886 in Grenada. That is, the brightness of the corona, as measured directly from the plates, will be only about *40 per cent* of that obtained from Mr. Barnard's plates of the California eclipse of January 1, 1889. Mr. Pickering's plates of 1886 were not developed for several months after the eclipse, and when developed the films were found to have deteriorated. The Cayenne plates showed also a great deterioration, due to dampness, though they were developed immediately after exposure. Precautions were, however, taken before the eclipse, which will possibly enable us to give a numerical estimate of the amount of change. Besides the eclipse plates ten others (A, B, C, D, E, F, G, H, I, J), were standardized by Mr. Barnard at the Lick Observatory, on September 24, 1889. A, B, C, D were taken to the eclipse and E, F, G, H, I, J remained at the Lick Observatory. I and J were developed on September 24, 1889, immediately after exposure. A and B were developed at Cayenne on December 22, 1889. E and F were developed at the Lick Observatory on the same day.

C and D were returned undeveloped to the Lick Observatory (arriving there March 5, 1890). G and H (still undeveloped) and C and D were then re-standardized by Mr. Barnard March 16th, and all four were developed together, March 17. Thus a complete history of the changes of these plates is available; and it is possible that a numerical factor can be obtained by which to multiply the measures of brightness obtained directly from the plates taken at Cayenne to obtain the results which they would have given had the eclipse occurred at Mt. Hamilton.

The practical result of this interesting experiment is to show that plates which are to be exposed in a damp climate should be hermetically sealed until they are exposed and again sealed immediately afterwards. The agreement between the results of Mr. Pickering's measures and those of December, 1889, shows that both are erroneous. The measures on the plates of January, 1889, are to be taken as correct, at least for the present.

Papers were also presented by Dr. H. Kreutz, of Kiel, on *Die Astronomische Gessellschaft*; by Mr. A. O. Leuschner, on The Orbit of μ^2 Hercules; by Professor Daniel Kirkwood, on The Similarity of Certain Asteroid Orbits. The meeting then adjourned.

After the adjournment of the regular meeting, a meeting of the Board of Directors was held to elect officers. Professor Holden was re-elected President; Messrs. Pierson, Soule, and Wythe, Vice-Presidents; Messrs. Schaeberle and Burckhalter, Secretaries, and E. J. Molera, Treasurer.

The next meeting of the Society will be held at the Lick Observatory, May 31, 1890.

CHARLES BURCKHALTER, Secretary.

THE METEORIC THEORY OF COMETS.

W. H. S. MONCK.

FOR THE MESSENGER.

As the meteoric theory of comets forms the ground-work of Mr. Lockyer's new theory of the stars and has, moreover, been accepted by many astronomers who are not prepared to accept Mr. Lockyer's hypothesis in its full extent, some further remarks on the subject may not be out of place.

I have already noticed that only four comets have hitherto been connected with meteor-showers and conversely only four meteor-showers have been connected with comets. This fact at once shows the breadth of the jump which we must take in order to reach their identity. To take a parallel case, Saturn's rings are generally believed to consist of collections of meteors; but are we thence to conclude that Saturn consists of meteors and then to extend this conclusion to all other planets and satellites? It might be indeed that only four comets have come close enough to the earth to bring us into contact with their meteor-trains. But if this be so, whence come the numerous meteor-trains which have not been connected with any comet? Moreover there are strong reasons for believing that we have come near enough to a number of comets to encounter their meteor-trains if they possessed such appendages. Lexell's comet (a brighter one than the trained comet of Biela) approached within 1,400,000 miles of the earth in 1770 and from the very small inclination of its orbit to the ecliptic, Lexellian meteors might have been expected to be met with, even at a considerable distance from the node. I do not, however, find any remarkable meteor-shower recorded on that occasion. The comet of 837, according to Mr. Chambers, remained for four days within less than 4,000,000 miles of the earth. This was a great comet and such a prodigy as a shower of falling stars in connection with it could hardly fail to have been recorded. The great comet of 1861, which Sir John Herschel regarded as the finest of the century, approached within a moderate distance of us, and it is believed that we actually passed through its tail. This last is an important element in the opinion of Mr. Lockyer, who says: "Meteorites are formed by condensation of vapors thrown off by collisions. The small particles increase by fusion brought about again by collisions and this increase may go on until the meteorites may be large enough to be smashed by collisions," (*Nature*, Vol. XXXVII., p. 56). Several other comets mentioned by Hind have made a close approach to the earth, among which I may refer to one of those of 1826. In none of these cases was a great star-shower observed.

It may be remarked that the four comets which have been

connected with meteor showers are all periodic, the longest period being 415 years. The fact may not be unimportant in connection with the theory of ejection advocated by the late Mr. Proctor. The recent instance of Krakatoa may suffice to show us that the increase of volcanic power which would be necessary to eject both stones and gases into space is less than might have been anticipated. Transfer Krakatoa to one of the asteroids, or even to the moon, and the ejection would become actual. Mr. Proctor indeed spoke of the ejection as taking place when the planet was "in the sun-like state," but it is evident that it might also occur after it had considerably cooled down. Now, while an ejection from the sun, or a sun-like body, might be purely gaseous, an ejection from a rapidly-cooling body would probably be partly solid partly liquid, and partly gaseous, like the products of our terrestrial volcanoes. The gaseous eject might thus form the comet, and the solid (or solidified) eject the attendant flight of meteors. For this origin of the four meteor comets, indeed, we must suppose two Ultra-Neptunean planets, but their existence is not unlikely on other grounds. Of the other two the Andromeda meteors and Biela's comet may have arisen in ejection from Jupiter and the Leonid meteors with their comet in ejection from Uranus

That the connection between the comet and the meteors is more likely to be of this character than to be one of absolute identity is suggested by various circumstances. The August or Perseid meteors are met with every year with but little difference in richness. Mr. Denning has seen them as early as the 8th of July and as late as the 25th of August. As the orbit of the corresponding comet is inclined to the ecliptic at an angle of over 66°, it is plain that at these dates (especially at the former) the earth is at a very considerable distance from any part of the comet's orbit; but of course a shower of stones, originating in a grand volcanic convulsion, might be very much scattered and cover a much wider space than the gaseous eject which originated at the same time. There is a curious shifting in the radiant of this meteor-shower noticed by Mr. Denning, the mathematical theory of which it would be very desirable to explain. Mr. Chambers (I do not know on what authority), sets down

the probable period of this meteor-shower at 108 years, while for the corresponding comet a period of 123 years has been computed. Again, the great meteor-shower of April 4th, 1095, was most probably a shower of Lyrids, whereas a period of 415 years, (as computed), for the corresponding comet would lead us back to 1030. The great meteor, (followed by a number of smaller ones), recorded in the Chinese annals in March, B. C. 74, also looks like a Lyrid, and as the shower is not often limited to a single year the period agrees very fairly with that indicated by the shower of 1095, but is several years shorter than that of the comet. It is hardly necessary to say that if the meteors followed the exact track of the comet we should not meet them at all, for there is no known comet whose orbit intersects that of the earth. The node is, in all cases, at some distance from the earth's track; but there can be no doubt that the meteors are often found at a considerable distance from the track of the comet, as well as at a very great distance from the comet itself.

Then, will the hypothesis that comets consist of clouds of meteors explain all the peculiarities which comets exhibit? Mr. Lockyer admits the contrary. "When a meteor-swarm approaches the sun," he says, "the whole region of space occupied by the meteorites (estimated by Prof. Newton in the case of Biela's comet to have been thirty miles apart) gives us the same spectrum, and further, it is given by at all events part of the tail which, in the comet of 1680, was calculated to be 60,000,000 miles in length. The illumination, therefore, must be electrical and possibly connected with the electric repulsion of the vapors away from the sun: hence, it is not dependent wholly on collisions" (*Nature*, Vol. XXXVII, p. 60): to which I may add that the meteoric theory affords no explanation of this electric repulsion. As Mr. Lockyer does not derive the entire light of the comets from collisions of meteorites and does not state how much of it comes from this source, it is not very easy to agree with him here. But let us remember that the individual meteorites are of small size and that they are moving in similar orbits with nearly equal velocities, so that even if we placed them thirty yards (instead of thirty miles) apart, the chances against any collision would be very great. More-

over, if a collision occurred, it would probably be a mere graze which would develop very little light or heat and produce no perceptible amount of vapor. I may refer to Saturn's rings in confirmation of this. No comet, I believe, has ever been seen at the distance of Saturn, though the dimensions are often greater than those of Saturn's rings. Consequently the interspaces must be much larger, relatively to the space occupied by the meteors, in the case of the comet than of the rings. Hence, collisions ought to be much more frequent in Saturn's rings than in any comet. But though Mr. Lockyer thought he had detected bright lines in Saturn's ring indicating such collisions, Dr. Huggins, on examining them with a more powerful instrument, could detect nothing but reflected light.

The theory that comets consist of clouds of meteors has been supposed to explain their transparency and their small mass. I do not think it explains either. If a comet either consists of a collection of solid bodies with void interspaces, or of a collection of solid bodies surrounded by gases or vapors caused by collisions, the mass (when the large volume of the comet is considered), must be considerable. In the former case the comet would not be visible at the distance at which we see it if the mass was very minute; in the latter case meteors moving nearly in the same direction and with nearly the same velocity could not generate this amount of vapor by collisions unless they were thickly packed together. It is, moreover, almost impossible that a collection of solid bodies should be visible at a distance and yet transparent. It is useless to argue, as Professor Tait does, that a single meteor at the distance of a comet could not hide a distant star. He might as well contend that because one rain-drop or one particle of dust could not hide a distant object, a heavy shower or a cloud of dust could not do so. Or perhaps a better analogy is that of a light haze which enables us to see objects at the distance of a mile almost as well as ever but hides a distant mountain-range which is visible on a clear day. But we can see stars through hundreds or even thousands of miles of comet, whatever the comet may be composed of; and it appears to me that the mass will be less and the transparency greater if we assume it to be purely gaseous than if we suppose it

to be made up in great part of solid, though small, bodies. The gaseous theory, too, is I think more in conformity with Mr. Lockyer's explanation, (previously given by me), of the retardation of Encke's comet. A shower of meteors fired into an approaching mass of gas would, I believe, retard its progress, but if fired into an approaching cloud of meteors it would strike a few colliding meteors out of the general mass, but those which escaped the collision would move on unimpeded. There would be a few killed and wounded, but the progress of the advancing column would not be delayed. The force of these arguments would be considerably strengthened if the latest results attained in certain departments of Astronomy could be relied on as absolutely correct. According to the latest estimate the mass of Saturn's rings is about double that of the planet Mercury. If the mass of Encke's comet at all approached this figure, its effects on the motion of Mercury would be very perceptible. But if it does not approach it, why are the collisions so numerous in the case of the comet and so few in the case of the rings? Again, Saturn's rings (except perhaps the inner gauze-ring), are not transparent, whereas it is computed that Arcturus was seen through 90,000 miles of Donati's comet with hardly diminished splendor. (If such a chance should again occur I hope the opportunity of making accurate photometric measures of the star will not be lost). The inference seems plain that the rings of Saturn are more than 1,000 times as dense as Donati's comet at the point where it crossed between us and Arcturus; but as regards collisions, the figures must (on the meteoric theory) be reversed.

I am not objecting to the Meteoric Hypothesis as a working hypothesis. As such it is, I think, entitled to stand beside the older Nebular Hypothesis; but we have made little progress toward establishing the truth of either. I am rather disposed to think that matter has always existed in its three conditions, the solid, the liquid and the gaseous; and that while some existing solids have been formed by the condensation of gases and some existing gases have been produced by the collision of solids, the relative proportions in the Universe have not been largely altered. At all events, I do not think the spectroscope will ever afford a crucial test between the Nebular and the Meteoric Hypotheses. It can

show, no doubt, that the body examined is partly solid and partly gaseous; and repeated observations of the same object may show whether the solid or the gaseous portion is on the increase. But I doubt if the spectroscope will ever distinguish between a large solid surrounded by a gaseous envelope and a number of small solids with the interspaces filled with gas. If I am correct in this view, Mr. Lockyer's spectroscopic observations have no bearing on his hypothesis. They may no doubt show that the heavenly bodies consist of the same chemical elements as the meteorites and ærolites which have fallen to the earth; but speaking generally this has long been known. Celestial bodies, indeed, afford indications of a small number of elements not hitherto discovered either in terrestrial bodies or meteorites; but supposing these exceptions removed, the question between the Nebular and the Meteorite Hypotheses would remain exactly where it was before. The results of Professor Newton's investigation, moreover, seem to indicate that all the meteorites, on whose spectra Mr. Lockyer experimented, had their origin within the limits of the solar system. Meteors coming from inter-stellar space would probably arrive with such high velocities as to insure their being dissipated in the air at a considerable altitude. The Meteoric Hypothesis must therefore be expounded generally and without any special reference to spectroscope results before it can claim general acceptance, unless, indeed, the spectroscope should hereafter enable us to distinguish between the light of a single large body and that of a number of small ones. I am, however, concerned only with that theory as regards comets, and with regard to these bodies I think it has not been proved.

Equations for an Ellipse through Five Given Points. "What is the equation, in Cartesian co-ordinates, of an ellipse passing through five points, x_1, y_1; x_2, y_2; x_3, y_3; x_4, y_4; x_5, y_5; or the simplest way of forming it?"

The five constants, a, b, c, d, e, from the five simple equations containing them and the co-ordinates of the given points, namely:

$$y_1^2 + ax_1y_1 + bx_1^2 + cy_1 + dx_1 + e = 0$$
$$y_2^2 + ax_2y_2 + bx_2^2 + cy_2 + dx_2 + e = 0$$
$$y_3^2 + ax_3y_3 + bx_3^2 + cy_3 + dx_3 + e = 0$$
$$y_4^2 + ax_4y_4 + bx_4^2 + cy_4 + dx_4 + e = 0$$
$$y_5^2 + ax_5y_5 + bx_5^2 + cy_5 + dx_5 + e = 0$$

Substituted in the equation

$$y^2 + axy + bx^2 + cy + dx + e = 0$$

gives the equation of the conic section passing through the five points, x_1, y_1; x_2, y_2, etc. The co-ordinates of its center are $\frac{ac + 2d}{4b - a^2}$ and $\frac{ad - 2bc}{4b - a^2}$.

R. J. ADCOCK.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be at greatest elongation east from the sun on May 5, and will be in a very favorable position for observation in the evening during the first half of the month. It will be visible to the naked eye for several days, between 8 and 9 P. M., in the west, not far from Venus. On May 29 Mercury will be at inferior conjunction, and so will not be visible during the latter part of this month or the first of next.

Venus is a conspicuous object in the west in the early evening. Reports have come to us of persons who have been able to see Venus in midday, but we have so far been unsuccessful in the attempt. Venus and Mercury will be in conjunction May 10, at 1 A. M., Mercury being 1° 45′ north of Venus. They will be near each other for several days. The red star Aldebaran will also be in the same vicinity.

Mars will be at opposition May 27. Its distance from the Earth at that time will be about 45,000,000 miles. During the opposition of 1892 the least distance will be about 35,000,000 miles, a little less than that at the opposition of 1877, when the satellites were discovered. At both the oppositions, of 1890 and 1892, it will be in extreme southern declination, for the planet, so that the best observations may be had in the southern hemisphere. The diameter of Mars' disk on May 27 will be 20.5″. He will be found in Scorpio, a little northeast of the red star, Antares, during the first part of the month, and northwest of that star at the end of the month.

Jupiter may be seen in the southeast in the morning among the faint stars of Capricorn.

Saturn will be at quadrature, 90° east from the sun, May 18. Probably most of our readers have noticed the retrograde or westward motion of Saturn during the last few months. He will now begin to move eastward, increasing the distance between himself and the stars of the Sickle.

Uranus may be found in the east in the evening in the Constellation of Virgo, about 4° northeast of Spica. He is in good position for observation.

Neptune will be in conjunction with the sun May 25, and so cannot be seen during this month.

MERCURY.

1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
May 25	4 38.6	+21 11	4 51 A.M.	12 25.4 P.M.	8 00 P.M.
June 5	4 16.9	+17 39	4 04 "	11 20.5 A.M.	6 37 "
15	4 15.6	+17 01	3 26 "	10 39.9 A.M.	5 53 "

VENUS.

May 25	5 54.7	+24 40	5 50 A.M.	1 41.4 P.M.	9 32 P.M.
June 5	6 53.3	+24 26	6 07 "	1 56.6 "	9 47 "
15	7 45.6	+23 00	6 27 "	2 09.2 "	9 52 "

MARS.

May 25	16 19.0	−23 05	7 39 P.M.	12 04.1 A.M.	4 29 P.M.
June 5	16 02.8	−22 58	6 39 "	11 04.5 P.M.	3 30 A.M.
15	15 50.1	−22 47	5 46 "	10 12.6 "	2 39 "

JUPITER.

May 25	20 59.0	−17 42	11 52 P.M.	4 43.2 A.M.	9 34 A.M.
June 5	20 58.9	−17 45	11 09 "	3 59.8 "	8 50 "
15	20 57.5	−17 53	10 29 "	3 19.1 "	8 09 "

SATURN.

May 25	10 01.7	+13 49	10 48 A.M.	5 47.7 P.M.	12 47 A.M.
June 5	10 04.0	+13 35	10 08 "	5 06.8 "	12 05 "
15	10 06.7	+13 20	9 33 "	4 30.1 "	11 28 "

URANUS.

May 25	13 26.4	− 8 26	3 42 P.M.	9 11.8 P.M.	2 42 A.M.
June 5	13 25.4	− 8 20	2 57 "	8 27.5 "	1 58 "
15	13 24.8	− 8 17	2 17 "	7 47.6 "	1 18 "

NEPTUNE.

May 25	4 10.1	+19 27	4 32 A.M.	11 57.2 A.M.	7 22 P.M.
June 5	4 12.0	+19 32	3 50 "	11 15.8 "	6 41 "
15	4 13.5	+19 36	3 12 "	10 38.0 "	6 04 "

THE SUN.

May 25	4 09.8	+21 02	4 23 A.M.	11 56.7 A.M.	7 30 P.M.
June 5	4 54.7	+22 36	4 17 "	11 58.3 "	7 40 "
15	5 36.1	+23 20	4 15 "	12 00.2 P.M.	7 45 "

CERES (1)

May 11	15 50.5	−12 43		12 30 A.M.	
June 4	15 28.8	−13 02		10 34 P.M.	
28	15 15.6	−14 20		8 47 "	

PALLAS (2)

May 23	15 04.5	+26 11		10 57 P.M.	
June 16	14 51.8	+25 21		9 10 "	

JUNO (3)

May 23	16 28.3	− 3 40		12 21 A.M.	
June 16	16 08.9	− 2 56		10 27 P.M.	

THE MOON.

May 20	5 26.8	+23 06	5 41 A.M.	1 33.3 P.M.	9 30 P.M.
25	9 52.0	+17 47	10 03 "	5 38.2 "	1 04 A.M.
30	13 52.9	− 6 58	3 27 P.M.	9 18.7 "	3 00 "
June 5	20 03.0	−23 27	10 36 "	3 04.9 A.M.	7 37 "
10	23 59.5	− 5 49	1 01 A.M.	6 44.1 "	12 35 P.M.
15	4 13.4	+19 27	3 08 "	10 37.7 "	6 16 "

[The above tables give local times for the Central Meridian and latitude +44° 28′.]

Phases of the Moon.

			Central Time. d h m
New Moon	1890	May	18 2 18 P. M.
First Quarter	"	"	26 4 34 P. M.
Full Moon	"	June	3 12 34 A. M.
Last Quarter	"	"	9 3 50 P. M.
Apogee	"	May	24 6 12 A. M.
Perigee	"	June	5 4 06 A. M.

Ephemerides of Saturn's Satellites.

[Computed by A. Marth, Monthly Notices R. A. S., vol. L, No. 1, p. 57. Reduced to Central Time.]

May 15	1.2 a. m.	Di. s.
	2.2 a. m.	Di. Ecl.?
	4.4 a. m.	Te. n.
16	1.0 a. m.	Rh. n.
	3.0 a. m.	Te. s.
	10.0 a. m.	Di. n.
17	1.7 a. m.	Te. n.
	4.1 a. m.	Rh. w.
	6.9 p. m.	Di. s.
	7.9 p. m.	Di. Ecl.?
18	12.4 a. m.	Te. s.
	7.2 a. m.	Rh. s.
	8.5 p. m.	Rh.c.Jap. 2".
	11.0 p. m.	Te. n.
19	1.5 a. m.	Tit. s. 37"
	3.7 a. m.	Di. n.
	10.3 a. m.	Rh. e.
	2.6 p. m.	En. n.
	4.0 p. m.	Jap.c. fol. end of ring 4" s.
	8.3 p. m.	Jap. Transit across ring. Ingress 3" s.
	9.7 p. m.	Te. s.
20	8.5 a. m.	Jap. Egress from ball 0".
	12.6 p. m.	Di. s.
	1.4 p. m.	Rh. n.
	1.6 p. m.	Di. Ecl.?
	2.4 p. m.	Jap. Transit across ring. Egress 2" n.
	3.0 p. m.	Jap. c. prec., end of ring 2" n.
	7.9 p. m.	Rh.c.Jap. 11".
	8.3 p. m.	Te. n.
May 21	4.0 p. m.	En. s.
	4.6 p. m.	Rh. w.
	7.0 p. m.	Te. s.
	9.5 p. m.	Di. n.
22	5.7 p. m.	Te. n.
	7.7 p. m.	Rh. s.
23	6.3 a. m.	Di. s.
	7.3 a. m.	Di. Ecl.?
	4.3 p. m.	Te. s.
	5.3 p. m.	En. n.
	10.8 p. m.	Rh. e.
24	3.0 p. m.	Te. n.
	3.2 p. m.	Di. n.
25	1.9 a. m.	Rh. n.
	1.6 p. m.	Te. s.
	12.0 mdn.	Di. s.
26	1.0 a. m.	Di. Ecl.?
	5.0 a. m.	Rh. w.
	12.3 p. m.	Te. n.
	7.4 p. m.	Tit. n. 33"
27	8.2 a. m.	Rh. s.
	8.9 a. m.	Di. n.
	11.0 a. m.	Te. s.
28	9.6 a. m.	Te. n.
	11.3 a. m.	Rh. e.
	5.8 p. m.	Di. s.
	6.8 p. m.	Di. Ecl.?
29	8.3 a. m.	Te. s.
	2.4 p. m.	Rh. n.
30	2.6 a. m.	Di. n.
	7.0 a. m.	Te. n.
	5.5 p. m.	Rh. w.
31	5.6 a. m.	Te. s.
	11.5 a. m.	Di. s.
	12.5 p. m.	Di. Ecl.?
	8.7 p. m.	Rh. s.
June 1	4.3 a. m.	Te. n.
	8.3 p. m.	Di. n.
	11.8 p. m.	Rh. e.
2	2.9 a. m.	Te. s.
3	1.6 a. m.	Te. n.
	2.9 a. m.	Rh. n.
	5.2 a. m.	Di. s.
	6.2 a. m.	Di. Ecl.?
4	12.3 a. m.	Te. s.
	1.0 a. m.	Tit. s. 33"
	6.0 a. m.	Rh. w.
	2.0 p. m.	Di. n.
	10.9 p. m.	Te. n.
June 5	9.2 a. m.	Rh. s.
	9.6 p. m.	Te. s.
	10.9 p. m.	Di. s.
	11.9 p. m.	Di. Ecl ?
6	12.3 p. m.	Rh. E.
	8.2 p. m.	Te. n.
7	7.8 a. m.	Di. n.
	3.4 p. m.	Rh. n.
	6.9 p. m.	Te. s.
8	4.6 p m.	Di. s.
	5.6 p. m.	Di. Ecl.?
	5.6 p. m.	Te. n.
	6.5 p. m.	Rh. w.
9	4.2 p. m.	Te. s.
	9.7 p. m.	Rh. s.
10	1.5 a. m.	Di. n.
	2.9 p. m.	Te. n.
11	12.8 a. m.	Rh. e.
	10.3 a. m.	Di. s.
	11.3 a. m.	Di. Ecl.?
	1.6 p. m.	Te. s.
	7.0 p. m.	Tit. n. 31"

En. = Enceladus; Di. = Dione; Jap. = Japetus; Mi. = Mimas; Rh. = Rhea; Te = Tethys; Tit. = Titan; c. = conjunction; e. = eastern elongation; w. = western elongation; n. = north of center of planet; s. = south of center of planet. The conjunctions of the three innermost planets with the ends of the ring take place in the case of Mimas about 3.0h, Enceladus, 3.2h, Tethys, 3.5h before and after the predicted conjunctions with the center, which are not observable.

Minima of Variable Stars of the Algol Type.

	R. A. h m s	Decl. ° ′	Approx. Central Times of Minima.
U Cephei	0 52 32	+81 17	May 17, 6 A. M.; 22, 6 A. M.; 27, 6 A. M.; June 1, 5 A. M.; 6, 5 A. M.; 11, 5 A. M.
δ Libræ	14 55 06	− 8 05	May 20, 2 A. M.; 28, 2 A. M.; June 4, 2 A. M.; 11, 1 A. M.
U Coronæ	15 13 43	+32 03	May 30, 3 A. M.; June 6, 1 A. M.; 12, 10 P. M.
U Ophiuchi	17 10 56	+ 1 20	May 19, 2 A. M.; 19, 10 P. M.; 24, 3 A. M.; 24, 11 P. M.; 30, 1 A. M.; 30, 9 P. M.; June 3, 12 MDN.; 4, 9 P. M.; 9, 1 A. M.; 9, 9 P. M.; 14, 2 A. M.; 14, 10 P. M.

Phenomena of Jupiter's Satellites.

	Central Time. d.	h. m.					Central Time. d.	h. m.			
May	16...	Midnight.	I.	Tr.	Eg.	June	1...	12 50 A.M.	I.	Oc.	Re.
	22...	2 16 A.M.	II.	Ec.	Dis.			11 16 P.M.	II.	Oc.	Re.
		2 45 "	III.	Ec.	Re.		2...	1 36 A.M.	III.	Tr.	Eg.
	23...	1 00 "	I.	Ec.	Dis.		7...	1 59 "	I.	Sh.	In.
	24...	12 32 "	I.	Sh.	Eg.			2 01 "	II.	Sh.	In.
		1 48 "	I.	Tr.	Eg.			3 05 "	I.	Tr.	Eg.
		2 09 "	II.	Tr.	Eg.			11 15 P.M.	I.	Ec.	Dis.
	29...	3 18 "	III.	Ec.	Dis.		8...	12 34 A.M.	IV.	Sh.	In.
	30...	2 53 "	I.	Ec.	Dis.			2 39 "	I.	Oc.	Re.
	31...	1 17 "	I.	Tr.	In.			10 47 P.M.	I.	Sh.	Eg.
		1 44 "	II.	Tr.	In.			11 52 "	I.	Tr.	Eg.
		1 49 "	IV.	Oc.	Dis.		9...	12 48 A.M.	III.	Sh.	Eg.
		2 17 "	II.	Sh.	Eg.			1 32 "	III.	Sh.	In.
		2 25 "	I.	Sh.	Eg.			1 40 "	II.	Oc.	Re.
		3 37 "	I.	Tr.	Eg.		15...	1 09 "	I.	Ec.	Dis.

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
May 20...	B.A.C. 1801...	6	8 00	32	8 30	329	0 30
June 3...	63 Ophiuchi...	6½	13 34	147	14 25	226	0 51
6...	χ Capricorni...	5½	13 53	347	Star 0.3′ N. of Moon's limb.		

COMET NOTES.

Comet 1882 II (*Great Comet*). A remarkable paper by M. F. Tisserand is contained in *Bulletin Astronomique*, Feb. 1890, on "The Nuclei of the Great Comet of 1882." It will be remembered that the nucleus of this comet, after its very close approach to the sun, separated into two, and afterward into as many as five separate nuclei lying in a straight line. The writer discusses the orbits of these nuclei, considering them as separate comets, neglecting their mutual attractions, which, he says, must be very small. By a differential method, taking as a basis the orbit of the brightest nucleus (2) calculated by Dr. H. Kreutz, he finds that the nuclei designated (2) (3) and (4) are moving in orbits which differ perceptibly only in the eccentricity, and the elements which depend upon this, the semimajor axis and period. Adopting the period of 772 years for nucleus (2), that for nucleus (3) becomes 885 years and that for (4) 972 years. The measures of the nuclei (1) and (5) were insufficient for the determination of their paths. The period of (1), which was nearest the sun, would naturally be less than that of (2).

The important conclusion to be drawn from these results is that we have here an explanation of the groups of comets which have been observed having almost exactly the same paths, but with periods so long as to exclude the possibility of their identity. The comets of 1843, 1880 and 1882 have very similar orbits, the greatest difference being in their eccentricities, which causes the great difference in their periods, 553, 37 and 772 years. It seems quite possible that at some time in the past these were parts of

one great comet which at its perihelion was separated into parts having different periods of revolution. Mr. Tisserand suggests the conjecture that the comet of 1880 was a fragment of that of 1843.

We may suggest also that both the comet of 1843 and that of 1882 may have been fragments of that of 370 B. C. According to Chambers the comet of 370 B. C. is said to have separated into two parts. The interval 2213 years divided by 4 gives 553 years for the period of the comet of 1843 and 2252 divided by 3 gives 751 years for that of 1882. These periods do not differ unreasonably from the results of the best computations.

Comet D'Arrest. The *Astronomische Nachrichten*, No. 2959, contains an ephemeris of D'Arrest's comet for its return during this year, computed by G. Leveau, of Paris. M. Leveau computed the elements of this comet from the observations made in 1870 and 1877, taking into account the perturbations by the planets, Jupiter, Saturn, and Mars, and calculated an ephemeris for the apparition of 1883, but the comet was too faint to be seen. Owing to other work M. Leveau has not been able to compute accurately the perturbations during the interval from 1883 to 1890, but has determined approximately those by Jupiter. The comet during this interval has been remote from Jupiter, so that the error arising from neglected perturbations cannot be large. The ephemeris gives ground for expecting that the comet may be found at this apparition. The reciprocal of the squares of the distances from sun and earth, $\frac{1}{r^2\Delta^2}$, reaches a maximum of 1.03 August 28, 1890, while during the observations in 1851 it varied from 1.50 to 0.60, in 1857 from 0.23 to 0.16, in 1870 from 0.89 to 0.15, and in 1877 from 0.20 to 0.15. As soon as the comet has been found a more exact ephemeris will be furnished. We give a part of the ephemeris for May and June:

Paris Mean Noon.	α app.	δ app.	$\frac{1}{r^2\Delta^2}$
	h. m.	° ′	
May 4	16 46.8	+ 7 12	
8	45.9	8 02	0.23
12	44.5	8 50	
16	42.6	9 36	0.28
20	40.2	10 19	
24	37.4	10 57	0.34
28	34.4	11 30	
June 1	31.1	11 57	0.41
5	27.7	12 17	
9	24.2	12 29	0.48
13	16 20.7	+ 12 33	

Comet 1889 I. Dr. R. Spitaler on March 28, 1890, rediscovered and observed this comet with the 27-inch refractor at the Vienna Observatory. Its distance from the sun was then almost five times that of the earth, and its distance from the earth almost exactly the same. No other comet has ever been observed at so great a distance from the sun. Its brightness is about one-twelfth of that which it had at the time of its discovery Sept. 2, 1888, and one hundred and twenty-ninth of its maximum brightness. The following continuation of Dr. Berberich's ephemeris is taken from *Astronomische Nachrichten, No. 2962.*

Berlin Midnight		α app. h m s	δ app. ° ′	log r	log Δ	Brightness.
May	11	18 22 57	−7 28.4	0.7304	0.6660	1.00
	13	21 00	7 24.8			
	15	19 01	7 21.3			
	17	17 00	7 18.0			
	19	14 56	7 14.9	0.7359	0.6638	0.98
	21	12 50	7 12.0			
	23	10 42	7 09.2			
	25	08 33	7 06.6			
	27	06 22	7 04.3	0.7413	0.6636	0.96
	29	04 10	7 02.1			
	31	18 01 56	7 00.1			
June	2	17 59 42	6 58.3			
	4	57 27	6 56.7	0.6466	0.6654	0.94
	6	55 12	6 55.3			
	8	52 56	6 54.1			
	10	50 40	6 53.1			
	12	48 24	6 52.2	0.7518	0.6693	0.91
	14	17 46 09	−6 51.6			

The brightness on March 28 is taken as unity.

Comet 1889 IV (Davidson.) In *Astronomische Nachrichten*, No. 2961, Herr A. Berberich gives the following elements of this comet, computed from six normal places:

$$T = 1889 \text{ July } 19.31081 \text{ Berlin mean time.}$$

$$\left.\begin{aligned} \omega &= 345^\circ\ 51'\ 57.6'' \\ \Omega &= 286\ \ 09\ \ 47.0 \\ i &= \ \ 65\ \ 58\ \ 41.1 \end{aligned}\right\}\ 1889.0$$

$$\begin{aligned} \log q &= 0.016890 & q &= 1.03966 \\ \log e &= 9.998479 & e &= 0.99650 \\ \log a &= 2.47325 & a &= 297.34 \\ \text{Period} &= 5127 \text{ years.} \end{aligned}$$

Mr. Campbell (*Astr. Jour.*, IX. p. 199) obtained a period of 3,000 years for the same comet.

A Group of Comets. In the same paper Herr Berberich calls attention to a group of seven comets of very long period which have elements quite similar to those of Comet 1889 IV, and which have all come from the same region about the south pole of the heavens.

Comet	T	ω	Ω	i	q	e	Period
1889 IV	July 19.3	345°52′	286°10′	65°59′	1.0397	0.99650	5100 yrs.
1881 III	June 16.5	354 15	271 05	63 26	0.7346	0.99643	3000 "
1888 I	Mar. 17.0	359 55	245 24	42 15	0.6987	0.99607	2300 "
1807	Sept. 18.8	4 08	267 56	63 10	0.6461	0.99549	1700 "
1880 V	Nov. 9.4	11 37	249 30	60 42	0.6527	1.0	
1885 V	Nov. 25.5	35 34	262 15	42 27	1.0790	1.0	
1684	June 8.4	330 35	271 08	65 49	0.9601	1.0	

Of these seven five have appeared within the last ten years. Three of them were discovered in the southern hemisphere with the naked eye, and two were discovered after perihelion in the northern hemisphere. The latter were observed through so short periods of time that the eccentricities of their orbits are uncertain. The importance is suggested of regular search for comets in the south polar regions of the sky.

Discovery of Comet Brooks (a 1890). On the morning of March 19, at 16 hours I discovered a nebulous object, which I at once felt confident was a comet, in R. A. $21^h\ 9^m + 5° 35'$. Dawn advanced, however, before I felt positive of the direction of motion, and three leading Observatories, viz., Harvard, Lick, and Warner, were telegraphically notified of my suspected object. The three succeeding mornings were cloudy, but this morning was beautifully clear and I at once found the comet less than one and one-half degrees north of its discovery place. Its position this morning (March 23, 16 hours) was $21^h\ 10^m\ 30^s$ decl. north 7° 15′, giving a daily motion of east 22 seconds, and north 25′. The comet is rather bright telescopic, with a stellar nucleus eccentric to the coma. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., March 24, 1890.

Comet a 1890 (Brooks). Mr. Brooks' letter containing description of the comet discovered by him on the morning of March 20 came too late for the last number of THE MESSENGER. Two sets of approximate elements have been received, one by Rev. G. M. Searle, of St. Thomas College, Washington, D. C. (*Science Observer*, Special Circular, No. 90), the other by Dr. Friederich Bidschof (*Circular der kaiserlichen Akademie der Wissenschaften in Wien*, No. lxxi).

Computer	Searle		Bidschof	
$T =$	1890 June 3.43 Gr. M. T.		1890 June 3.6399 Ber. M. T.	
$\omega =$	74° 01′	1890.0	71° 07′ 36″	1890.0
$\Omega =$	320 46	1890.0	320 44 54	1890.0
$i =$	122 00	1890.0	121 17 13	1890.0
$q =$	1.7830		1.8702	
Dates of obs.	Mar. 22, 24, 25.		March 22, 25, 29.	

We have no ephemeris at hand extending beyond May 4. The comet is growing brighter and coming into better position for observation. It may be found in the northeast soon after midnight.

Berlin Midnight.	α app. h m s	δ app. ° ′	log r	log Δ	Brightness.
April 30	21 00 34	+29 23.3	0.2830	0.2743	2.39
May 1	20 59 31	30 12.4			
2	58 23	31 02.3			
3	57 10	31 52.9			
4	20 55 51	32 44.3	0.2806	0.2578	2.62

The brightness on March 21 is taken as unity.

Solar Prominences.—March. Number of observations, 12; number of prominences, 45; mean number of prominences, 3.75; greatest number in one day, 7 (on 4th inst.); highest prominence, 54″ (18th inst.).

DISTRIBUTION OF PROMINENCES.

	E. Limb.	W. Limb.		E. Limb.	W. Limb.
0 to 10	1	0	0 to − 10	2	3
10 to 20	0	0	− 10 to − 20	0	2
20 to 30	2	0	− 20 to − 30	0	3
30 to 40	0	0	− 30 to − 40	0	0
40 to 50	1	0	− 40 to − 50	1	1
50 to 60	2	0	− 50 to − 60	0	0
60 to 70	2	0	− 60 to − 70	5	1
70 to 80	2	1	− 70 to − 80	0	3
80 to 90	7	4	− 80 to − 90	2	0
				27	18

Camden Observatory.

Carleton College Sunspot Observations. Continued from page 136.

Date.	Central Time.	Groups....	Spots....	Faculae....	Observer..	Remarks.
1890						
Feb. 21.	10.20 A. M.	0	0	0	H. C. W.	
" 27.	2.15 P. M.	1	1	2 gr.	"	Small spot with bright fac. near W. limb.
" 28.	11.45 A. M.	1	1	2 gr.	"	
Mar. 1.	12.30 P. M.	0	0	1 gr.	C. R. W.	
" 4.	3.00 P. M.	1	4	1 gr.	"	
" 5.	12.40 P. M.	1	3	1 gr.	"	Two very large spots.
" 6.	12.30 P. M.	1	6	1 gr.	"	
" 13.	10.30 A. M.	1	3	2 gr.	H. C. W.	Large groups of faculae.
" 14.	12.35 P. M.	0	0	2 gr.	C. R. W.	Faculae NW. and NE.
" 15.	3.10 P. M.	0	0	2 gr.	"	Faculae not very distinct.
" 22.	5.00 P. M.	1	2	1 gr.	"	Spots small. Large group of faculae W.
" 30.	5.00 P. M.	0	0	0	"	
" 31.	10.00 A. M.	0	0	0	"	
April 4.	12.30 P. M.	0	0	0	"	
" 9.	12.30 "	0	0	2 gr.	"	
" 10.	12.30 "	1	3	2 gr.	"	Spots small E. of center. Fac. E.
" 11.	12.30 "	2	4	2 gr.	"	
" 16.	12.30 "	0	0	1 gr.	"	Faculae very near W. limb.
" 17.	12.25 "	0	0	0	"	
" 18.	12.20 "	0	0	0	"	

Smith Observatory Observations. The following solar observations were made in March and April, 1890, with helioscope, powers 98 and 221:

1890.	90 M. M. T.	Groups..	Spots....	Faculae.	Seeing.	Remarks.
1 Mar.	11.30	0	0	0	Poor.	Suspected fac. near E. limb.
2 "	2.50	0	0	0	Very poor.	Hazy clouds.
3 "	2.00	1	3	1 gr.	Fair.	Brilliant fac. surrounding whole group.*
4 "	2.00	1	3	0	Poor.	Fac. still surrounding; nucleus smaller.
5 "	2.00	1	3	0	Very poor.	Fac. same; P. spot now larger.
6 "	3.40	1	4	0	Fair.	P. spot dividing, fac. surrounding.
7 "	11.00	1	4	0	"	P. spot broken in two; fac. less prominent.
8 "	3.10	1	4	0	"	Surrounding fac. diminished.
12 "	2.30	1	3	1 gr.	Poor.	Fac. near E. limb.
13 "	11.00	1	3	2 gr.	Good.	New fac. about spots; brief fac. on S. E. limb.
14 "	2.20	1	1	2 gr.	Fair.	Spot very faint; fac. extended far S.
15 "	2.25	0	0	1 gr.	Very poor.	Gran. difficult; fac. very dim.
20 "	10.00	0	0	0	Fair.	
21 "	11.15	0	0	1 gr.	"	Fac. on E. limb.
22 "	3.00	1	2	1 gr.	Good.	Spots very minute; Fac. near circle 20″ diam., very bright.
23 "	1.00	0	0	0	Poor.	Gran. dif.
24 "	2.25	0	0	0	Bad.	Results negative; clouds.
26 "	11.40	0	0	0	Poor.	Unsatisfactory seeing.
29 "	2.20	0	0	0	Good.	Gran. visible to limb.
30 "	4.20	0	0	0	Poor.	Sun too near horizon.
31 "	11.45	0	0	0	"	Haze; nothing more at 2.15 P. M.
1 April.	12.00	0	0	0	Fair.	No change at 2.30 P. M.
2 "	12.00	0	0	0	"	Gran. fair.
3 "	4.40	0	0	0	"	Two or three bright regions, not quite fac.
4 "	2.45	0	0	1 gr.	Good.	Gran. good; fac. on E. limb.
5 "	4.45	0	0	1 gr.?	Fair.	Suspected fac. on E. limb.

* Nucleus of f. spot extended almost to limb. Mr. Frost, in the April number o THE SIDEREAL MESSENGER, notes prominences on 3rd, and spot on 4th. At above date eruptive prominences were observed directly over each of the three spots, the highest prominence over the largest spot.

1890.	90 M. M. T.	Groups...	Spots....	Faculae..	Seeing.	Remarks.
6 April	12.00	0	0	0	Fair.	Slight haze.
7 "	12.30	0	0	0	Poor.	Gran. fair.
8 "	12.40	0	0	0	Fair.	At 2 P.M. seeing good, gran. good.
10 "	12.00	0	0	0	Poor.	Gran. dif.
11 "	11.30	2	4	0	Good.	One spot N., ⅔ across; 3 spots S., ⅓ across; gran. good.†

Smith Observatory, Beloit College, CHAS. A. BACON.
April 11th, 1890.

NEWS AND NOTES.

The attention of foreign subscribers is called to the fact that foreign money orders, in payment of dues to THE MESSENGER, should be drawn on St. Paul, for our convenience in collection.

The notice of the discovery of the first comet for 1890, by Professor Brooks, came too late for our last issue, but appears elsewhere in this number, that its record may be complete.

Donohoe Medal of the Astronomical Society of the Pacific. We are pleased to learn that Professor William R. Brooks, of Geneva, N. Y., has been awarded the Donohoe Medal of the Astronomical Society of the Pacific, for the discovery, on March 19, 1890, of the first comet of the year, elsewhere described. It is the first award of this medal by the Society and a deserved honor for Professor Brooks.

Astronomical Society of the Pacific. It is also most gratifying to call the attention of our readers to the phenomenal progress that the Astronomical Society of the Pacific has made during the past year, which is the first year of its history. We do not know anything like it in the history of our science. To our mind it shows the wisdom of bringing the professional astronomer and the amateur in close relation that both may share the advantages of what neither could accomplish alone. The popular influence of such united effort is manifestly excellent.

Observatory Local Patronage. The last month has developed some interesting phases of the question of local patronage for local observatories. One step has been taken which has meaning in it, and that is the preparation of a memorial to be used as shall be decided on later, setting forth the views of astronomers generally concerning the relations of the U. S. Naval Observatory and the Western Union Telegraph Company, and the effect of the same on local Observatories. The signing of this memorial by astronomers in all parts of the United States and by some in

† At 4.20 P. M. 1st and 2nd spots had drifted together and 2nd nucleus had literally cracked into six distinct parts; three new spots (minute) had appeared N. of 3rd spot. Required power of 221 to resolve the "cracked" appearance.

Canada, shows a universality of feeling that was not expected a month ago. Not only this, but there are many who think the time has come when further important steps should be taken to co-ordinate some branches of science in which the Government is interested, and give them a head and management such as they deserve. This memorial is already in the hands of those who will give it the prompt and earnest attention it deserves.

The Western Union Time. Our readers who have had access to the leading dailies of the country already know what has been going on during the last thirty days. Those who have not and care to know may, with advantage, read articles found in the *New York Herald*, March 30 and 31; *Pittsburgh Dispatch*, April 1; *Chicago Tribune*, March 29; *St. Paul Globe*, March 27; also the *Chicago Tribune* of March 28. The remarks of the Superintendent of the United States Naval Observatory in the last named paper concerning us personally are so disgraceful that they are unfit to copy, much less to answer. The language of the slum and the brothel which the snperintendent relishes so well shall have no place in THE MESSENGER. Accidents in official place find their true level in time and sometimes speedily. Our friends are exhorted to keep their patience.

Melbourne Observatory. A very neat volume of 131 pages has been received containing the results of astronomical observations made at the Melbourne Observatory, in the years 1881, '82,' 83,' 84, under the direction of Robert J. Ellery, Government Astronomer to the Colony of Victoria, Australia.

This volume has an introduction of 20 pages describing the position of the Observatory, the personal establishment, the instrument, mainly the transit-circle, whose object-glass is five inches aperture with focal length of 72 inches, the transit-circle observations, zenith distance observations and manner of printing observations. Then follows the tabular part of the volume, first the work for the year 1881, in which the separate results for mean right ascension of stars, and the separate results for mean north polar distance and then another table showing the mean of individual observations for the same stars numbering 173, in all. For the year 1882 a catalogue of 196 stars was made in the same way, in 1883 the catalogue contained 376 stars, and in 1884, 347.

The convenience of form and neatness and care in detail make this publication a model one, so far as appears from a brief examination.

New Variable Stars in Cygnus. Photographs of the spectra of the fainter stars are now being taken at the Harvard College Observatory with the 8-inch Draper telescope. Their examination by Mrs. Fleming has led to the detection of various interesting objects. The star DM. $+48°$ 2942, whose position for 1900 is in R. A. $19^h\ 40.8^m$; Dec. $+48° 32'$, was found to give a spectrum so closely resembling that of *o* Ceti and other variable stars of that class that its variability was at once suspected. A photographic chart of this region was therefore taken and a comparison with previous photographs proved conclusively that the star was variable. Argelander estimated its brightness as 7, July 28, 1842, and it is given as 7.1 in

the Durchmusterung. Photographs taken on November 30 and December 1, 1887, show that it was then fainter than the magnitude 11, while on March 30, 1890, it was brighter than the magnitude 7. The photographs at Cambridge cover the greater portion of the sky several times and often permit a suspected discovery to be confirmed without examination of the sky. EDWARD C. PICKERING.

Harvard College Observatory, Cambridge, April 12, 1890.

A Simple Break-Circuit for Clocks. In the March MESSENGER we published a brief article by Willard P. Gerrish, descriptive of a simple break-circuit for clocks which we had no knowledge of before, and which Mr. Gerrish also believed to be new. From later correspondence, however, it turns out, undoubtedly that Mr. Gerrish reports a rė-discovery of a method that haselse where been in use for a long time.

Under date of April 4, Charles H. Chandler, Ripon College, Wis., writes: "The simple break-circuit for clocks, described by Mr. Gerrish in the March MESSENGER, is the same in principle as one employed in Dartmouth College Observatory more than twenty years ago by Professor C. A. Young. I think a mercury contact was employed instead of platinum, but the permanent horse-shoe magnet swinging near the light armature was employed to make the circuit. I have also used a similar device upon an 'Atwood's Machine.' By placing the armature upon one end of a light lever, and counterpoising it with a weight screwed upon the other end of the lever, an admirable delicacy and certainty of adjustment is practicable."

Desiring further information about this interesting device, we asked Professor Young for it. Under date of April 9, he replied as follows:—"Mr. Chandler is quite right. In 1867, I had in use, at the Observatory at Hanover, a break-circuit precisely like that described by Mr. Gerrish, and gave it up because it was not always certain in its action, sometimes failing to break on account of a slight *welding* by the spark at the point of contact."

"As I know now, that could have been easily remedied by making the contact-points of *gold* instead of platinum, but I did not know it then. I had also used a similar break-circuit three or four years before at the Observatory of the Western Reserve College then at Hudson, Ohio."

"But the idea was not original with me—at least Dr. Brunnow of Ann Arbor was earlier. The earliest description of the device, so far as I know, is that given by him about 1859 in No. 19 of the 'Astronomical Notices'—my reference being derived from a paper now before me reprinted from the Journal of the Franklin Institute. This paper (the date of which is not given but it must be between 1862 and 1864) describes and figures a modification of this break by Mr. Robinson (now Professor Robinson of Champaign, Illinois) which was in use in 1864 on two of the clocks used by the Lake Survey Longitude parties. It gave trouble occasionally by "sticking"—*i. e. welding*, as already mentioned was the case with the form I afterward employed, which had a horseshoe magnet below the pendulum instead of the single pole magnet of Robinson."

"The magnetic break is objectionable, theoretically, at least, because variations of temperature alter the attraction between magnet and arma-

ture and so affect the rate of the clock. It is very sensative to slight changes of distance between magnet and armature."

Stellar Parallax. We have inadvertantly omitted to call attention before to a most useful article in *Knowledge* for February by Herbert Sadler on Stellar Parallaxes. In that paper is given a list intended to include all parallaxes published from 1800 to the end of 1889. In this list is given the ordinary designation of the star, its approximate place for 1890, the magnitude roughly to the nearest half in the photometric scale, the name of the observer or publisher of the determinations, the date, the method of observation, the aperture of the instrument employed, a reference to the place of publication, and the actual parallax and probable error as determined by the observer. Though not given the distance of each star in light years in the list could easily be found by dividing 3.262 by its parallax in seconds. This article is so important that we will soon give it place in the MESSENGER. It is hoped that Professors Hall and Elkin will continue the work, and possibly Professor Holden will soon do something in the same direction.

Professor H. A. Howe, Director of the Chamberlin Observatory, of the University at Denver, Colorado, is planning to build a Students' Observatory. This will give much needed facility in connection with the larger Observatory already in process of construction. The student work, by this plan, will not interfere with other in progress by the instruments of the large Observatory. His plan is to have a six-inch equatorial and a two-inch transit for student use. Mr. Brashear, of Allegheny, and Mr. Saegmuller, of Washington, will build the instruments. Mr. Saegmuller reports that the definition of the objective that has been selected is simply "superb."

The Transactions of the Twentieth and Twenty-first Annual Meetings of the Kansas Academy of Science for the years 1887 and 1888 appear in a neatly printed book of 127 pages. A copy is kindly sent us by Librarian B. B. Smith, Topeka, Kansas.

Dust Particles in the Air. An ingenious method has been devised by Mr. John Aitkin for counting the dust particles in the atmosphere. It was found that when the moisture is condensed in a rarified atmosphere each rain-drop has a dust particle for its nucleus, so that by sweeping a measured portion of the air into an exhausted receiver, by means of pure air, and counting the number of deposited drops, it is easy to calculate the number of dust particles in a given volume of the impure air. The counting is managed by having the silver plate in the receiver divided into millimeter squares, so that it is only necessary to count the drops on one square millimeter. Mr. Aitkin showed that the air of a hall contained 400,000 particles to the cubic centimeter, while a specimen of air taken near the roof of the hall gave 3,500,000 to the cubic centimetre. In Edinburgh, on a fine day after snow the number of dust particles in the cubic centimeter was 75,000, but in pure country air the number is often as low as 5,000.—*Science News.*

"*The Chief Discoverers of Comets.*" The revised table given by Professor Swift in THE SIDEREAL MESSENGER, April, 1890, p. 189, differs from mine owing to a difference of method in compilation. In my list, SID. MES., March, p. 122, I counted as discoveries some returns of periodical comets, whereas Professor Swift has omitted these. There is no doubt that a discoverer of an unexpected comet deserves vastly more credit than an observer who, by means of an ephemeris is the first to pick up a periodical comet at its return to aphelion. But it is usual in cometary statistics to give the names of these first observers of returning periodical comets as "discoverers." Thus in Chambers' Catalogue we find their names classed under this heading.

In summarizing results of this character no two persons are likely to agree exactly, because each one will accept or reject details according to his opinion of the circumstances. Thus in my table I included two comets found by Pons in 1808, though not observed sufficiently for their orbital elements to be ascertained. I presume Professor Swift rejected these observations thinking that owing to the want of corroboration Pons was hardly entitled to the merit of discovery.

Professor Swift not very charitably ascribes the differences in our tables to errors existing in mine, but I cannot find any justification for such a statement. Professor Swift is himself in error in attributing 26 comets as the number discovered by Pons, and there are other defects in his table, one of the most serious of which is the entire omission of Messier's name. The latter was the most pertinacious and most successful comet seeker of the last century. W. F. DENNING.

Bristol, April 10, 1890.

American Metrological Society. We have been favored with a copy of the Constitntion of the American Metrological Society and the list of officers for the year 1890. This important organization has for its objects the improvement of existing systems of weights, measures, and money, and to bring them into relations of simpler commensurability with each other. Also to secure universal adoption of common units of measure for quantities in physical observation or investigation, for which ordinary systems of metrology do not provide; such as divisions of barometer, thermometer, and densimeter; amount of work done by machines; amount of mechanical energy, active or passive, of bodies, as dependent on their motion or position; quantities of heat present in bodies of given temperatures, or generated by combustion or otherwise; quantity and intensity of electrodynamic currents; aggregate and efficient power of prime movers; accelerative force of gravity, pressure of steam and atmosphere, and other matters analogous to them; and to secure uniform usage as to standard *points of reference*, or physical conditions to which observations must be reduced for purposes of comparison; especially temperature and pressure to which are referred specific gravities of bodies, and the zero of longitude on the earth.

Further, to secure the use of the decimal system for denominations of weight, measure, and money derived from unit-bases, not necessarily excluding for practical purposes binary or other convenient divisions, but

maintained along with such other methods, on account of facilities for calculation, reductions, and comparison of values, afforded by a system conforming to our numerical notation.

The modes of operation chosen by the Society are very general and specifically stated in the constitution. The plan is a very comprehensive one and deserving of success. The officers of the present year are:

President, B. A. Gould, Cambridge, Mass. Vice-Presidents: T. R. Pynchon, Hartford, Conn.; Sanford Fleming, Ottawa, Canada; T. C. Mendenhall, Washington, D. C.; T. Egleston, New York City; R. B. Fairbairn, Annandale, N. Y.; J. H. Van Amringe, New York City. Treasurer and Recording Secretary, John K. Rees, New York City. Corresponding Secretary, O. H. Tittmann, Washington, D. C. Members of the Council: H. A. Newton, New Haven, Conn.; Cleveland Abbe, Washington, D. C.; R. H. Thurston, Ithaca, N. Y.; A. M. Mayer, Hoboken, N. J.; C. F. Brackett, Princeton, N. J.; W. F. Allen, New York City; Simon Newcomb, Washington, D. C.; S. P. Langley, Washington, D. C.; E. O. Leech, Washington, D. C.; Geo. Eastburn, Philadelphia, Penn.

The Motion of Hyperion. No. 2 of Vol. 5 of the Annals of Mathematics contains an elaborate article on the motion of Hyperion, by Professor Ormond Stone, Director of the Leander McCormick Observatory of the University of Virginia. In this article, it is first assumed that the planes of the orbits of Titan and Hyperion coincide and the differential equations for the motion of the latter are then written. The co-ordinates which result are only approximate and more accurate ones could be found by a repetition of the same process. It is, however, suggested that the solution can not even be considered as approaching completion until the values of one of the variables are obtained by a comparison of an assumed orbit with observations made near conjunction, and distributed, if possible, over the whole nineteen years, during which another variable makes a cycle of 360°. Professor Stone also suggests that the method used in this article may also be readily extended to cases in which the disturbed and the disturbing bodies do not move in coplanar orbits. The asteroids furnish quite a number of interesting cases of mean motions nearly commensurate with that of Jupiter. As examples, may be mentioned (153) Hilda and (190) Ismene, whose mean motions are each approximately three halves that of Jupiter.

Honor for Professor Holden. The Astronomical Society of France at its last meeting elected Professor E. S. Holden, Director of Lick Observatory, one of its Honorary Members.

Professor W. A. Crusenberry of Garfield University, Wichita, Kansas, sometime ago sent us a graphic solution of the two simultaneous equations $x^2 + y = 7$ and $x + y^2 = 11$. The geometric figure is a neat one and though not difficult to get, it will soon be given as bearing on some points raised by different persons interested in the algebraic solution to find the values of x and y.

Spectroscopic Observations of Algol. In answer to the queries of an interested reader of the MESSENGER, for information concerning spectroscopic observations of the variable star Algol, we give in full a brief article that appeared in No. 209 of the *Astronomical Journal* as follows:

At the session of the physico-mathematical class of the Berlin Academy of Sciences held November 28, Dr. Auwers presented the following results of the spectrographic observations of the variable star *Algol*, by Professor Vogel and Dr. Scheiner.

Three impressions of the spectrum, taken last winter, had already given evidence that *Algol* recedes from the sun before a minimum, and approaches it after a minimum, Notwithstanding that the lines of the *Algol*-spectrum are not well adapted for accurate measurement, still every impression gave the direction of the motion beyond all doubt, and permitted the determination of its amount with tolerable approximation.

Three new impressions, made within a few weeks, have afforded results completely accordant; and the hypothesis,—long ago proposed but for the most part abandoned since then, on account of the great mechanical and physical difficulties which it entails,—that the variation of *Algol's* light is to be attributed to eclipse by a dark companion revolving around it, now recieves strong support again from these observations

The motion of revolution for the visible star may, from the mean of the six measurements, be assumed as 5.7 geographical miles [42 kilometers*]. Furthermore, the assumption of a circular orbit, described with this velocity, gives when combined with the period of variation, an arrangement of the system somewhat thus:—

Diameter of the principal star	230,000 miles	[1,700,000 km]
" " " dark companion	180,000 "	[1,322,000 "]
Distance of their centers	700,000 "	[5,200,000 "]
Orbital velocity of the companion	12.0	[88 "]

Masses of the two bodies, four-ninths and two-ninths of the sun's mass.

The several results of the observations now at hand are as follows:

	Potsdam M. T.		Distance from Minimum	Obs. motion toward earth	Reduction to sun	Star toward sun at observation	Observation re-r'd to nearest quadrate	Weight
	d	h	h	M.	M.	M.	M.	
1888 Dec.	4	6.6	11.4 after	—5.0	—1.2	—6.2	—7.1	½
1889 Jan.	6	5.7	22.4 before	+6.9	—3.0	+3.9	+4.3	1
"	9	5.5	19.4 before	+7.5	—3.1	+4.4	+4.5	1
Nov.	13	9.3	13.3 after	—5.6	+0.2	—5.4	—5.7	1
"	23	9.0	22.3 before	+6.2	—0.5	+5.7	+6.5	1
"	26	8.5	19.6 before	+6.8	—0.7	+6.1	+6.2	½

Consequently the mean of the observed motions, reduced to quadrature, is
Before minimum, +5.3 miles. After minimum, —6.2 miles.

Wolsingham Observatory. Bright lines were seen in the spectrum of θ_1 as well as in θ_2 Orionis, March 26, and in S Coronæ possibly also April 1, 1890.

T. E. ESPIN.

* A German geographical mile represents the fifteenth part of a degree on the terrestrial equator, or about 7.4 kilometers.

Bulletins of the U. S. Scientific Expedition to West Africa. We have been favored by Professor Todd with bulletins of the U. S. Scientific Expedition to West Africa, numbered 7, 9, 10, 11 and 12, which make our series complete to the last number above named, excepting the first. We have before spoken of other numbers. No. 7, bearing date Nov. 15, 1889, is a paper on a Provisional List of Mammals of Angola and Vicinity, prepared by F. W. True, Curator of Mammals of the National Museum, Washington, D. C. Nos. 9 and 10 are dated December 10, 1889, and contain instructions and suggestions for observing the total eclipse on the 22d of the same month. These were prepared by Professor Todd. No. 11 bears date Dec. 24, 1889, with title, "Terrestrial Physics." This paper was prepared by E. D. Preston. Some of its interesting points are:

That observations of the force of gravity at different points of the earth's surface have brought out the fact that islands are relatively heavy and continental mountains light. The most notoble case is Pinchincha in Peru, at which a density of about one-fifth was deduced for the mountain and the underlying strata. At Halsakala, a mountain in the Hawaiian islands, the density was at least equal to that of the surface rocks. An interesting study for gravity determinations will probably be brought out by this expedition, bearing on some important questions. Bulletin No. 12 is dated Dec. 31, 1889, and signed by Professor Todd, and has for its title, "The Total Solar Eclipse." The substance of this interesting number has already appeared in previous numbers of this journal by kindness of Professor Todd and members of his party.

The Mathematical Magazine. No. 1 of Vol. 2 of this valuable magazine has been received. It is published by Artemas Martin, LL. D., U. S. Coast and Geodetic Survey, Washington, D. C. Quarterly; price one dollar a year in advance.

Knowledge, of April first contains a short letter from Professor Hall, calling attention to what he believes to be the real advantages of the photographic method in astronomical investigation, and also suggesting the possibility of unwarrantable confidence in the exactness of the method. On the latter point he says: "The discussion of the American photographs of the transits (of Venus) of 1874 and 1882, nearly two thousand in number, gives for the probable error of the position of Venus from a single plate about half a second of arc; that is, the photographic method has approximately the same degree of accuracy as an observation with a meridian circle.

Photographics Notes. Monthly Notices for February gives brief records of work done in various departments of celestial photography. The subjects treated are: Professor Pritchard's researches in stellar parallax; Professor H. C. Vogel's investigations of the motions of stars in the line of sight; the work of Professor Pickering, Dr. Scheiner, and Professor Charlier in the line of photometry; and proposed charts of the heavens. Some short quotations from these records follow.

"There can be little doubt that for the delicate work of stellar parallax

as applied to the fainter stars the photographic method must ultimately prevail over all other methods by micrometers or by heliometers." "Six photographs of Algol taken in 1888 and 1889 show a distinct change of motion to be connected with its light period, namely, that before minimum it is receding at the rate of 24.4 English miles per second, while after minimum has been passed the star approaches us with the velocity of 28.6 miles per second. From these velocities it follows that the system of Algol is approaching our system at the rate of 2.3 miles per second, and that the visible star has a velocity in its orbit of 26.3 miles per second. . . Professor Vogel wishes these results to be regarded as provisional only.

Three catalogues of star magnitudes have been prepared by the photographic method at the Harvard Observatory. The first and third of these catalogues is deduced by the method of trails. The second contains magnitudes of stars in the Pleiades group, determined by comparing discs of two stars in the Hyades with those on the Pleiades plates.

Venus in Daylight. Under date of April 8, Mr. A. Cameron, Yarmouth, Nova Scotia, writes that he saw at one o'clock P. M. of that day, the planet Venus distinctly, with the naked eye. He says the sky was perfect. A roof and a couple of chimneys enclosed her and an L on the house shut off the sun.

BOOK NOTICES.

FAITH HEALING. A Defense, or, The Lord thy Healer. By R. L. Marsh, B. D. Fleming H. Revell, Publisher. New York, 12 Bible House, Astor Place. Chicago, 148 and 150 Madison Street. Pp. 147.

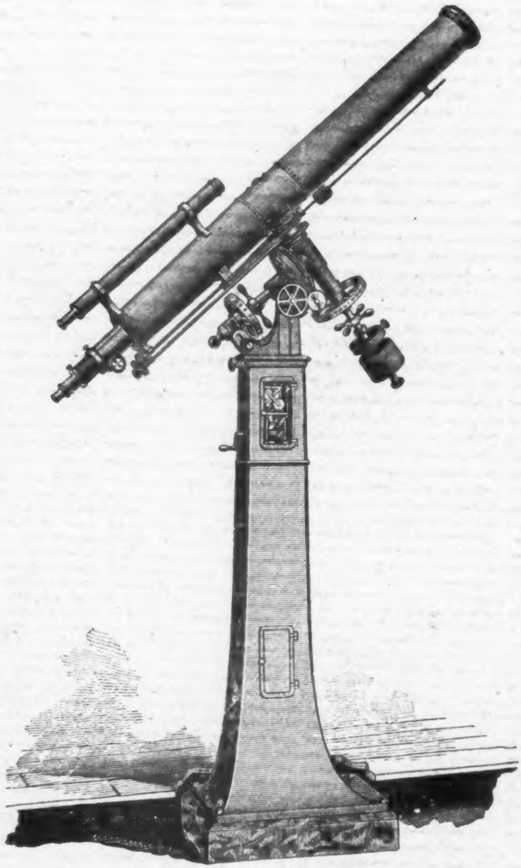
The sentence on the title page suggests the important truth which this new book undertakes to unfold. "It is Christ's words: Whether it is easier to say, Thy sins are forgiven, or to say Arise and walk." There are many thoughtful persons who are asking the question whether the belief that is called "Faith Healing" or Divine Healing is true or not. The friends of this doctrine are heard from in all parts of the world, and some very wonderful things are related by them, the half of which, if true, should lead to careful examination of the facts that the needs of humanity might be met and served in better way if there is new or better balm in Gilead than latter day physicians have known. However this may be, this little book is the outgrowth of one person's experience, through several years of searching for truth with reference to the subject of Faith Healing so-called. The writer says that the Scripture argument is that which at last convinced him, and he put it in writing, as a graduating thesis to be presented with the final examinations to the Faculty of Yale Theological Seminary. By the encouragement of some of the Faculty and other friends the writer's studies have finally assumed the present form. The modest way in which he introduces himself, as he undertakes a most difficult task is very becoming, and we do not see that he sacrifices anything, or loses any strength of position, by saying that he does not yet know all the truth, and does not expect to answer every objection that may be urged against what he shall say, but simply to state doctrine of this mode of healing as he finds it in the Scriptures.

The author's first point is to object to the title of "Faith Healing," because that name is misleading, in that it directs attention to human agency in cure, instead of the divine. Healing is by faith in the same sense that justification is by faith, not the means nor necessarily always the condition of blessing in this way, but it is simply the procuring *act*. It is by the power of God *through* faith in his name. Hence, a better name is Divine Healing.

A brief outline of the doctrine, as given in the first chapter is this: "The Old and New Testaments present the same teaching concerning the cause or origin of disease, and the means of escape from it. The cause of disease is, in general, the devil;" escape from it is through atonement, more fully stated; Deliverence from sickness is one of the conditional blessings of Jehovah's covenant with Israel. The unfaithfulness of the people prevented any full realization of the blessing, yet a recognition of its possibility continued throughout their history. This hope is a large part of the Messianic prophecy. The power and privilege of healing in Christ's name He gave to His disciples as a part of the Gospel and distinctly promised that it should be continued wherever that Gospel was preached. Both earlier and later apostolic teachers confirm and continue that promise.

This is a very brief and very general outline of the subject matter of this book, as it appears from more than twenty different topics in as many different chapters. Christian people commonly believe most of the first part of this outline, but very generally they do not believe that the power which Christ exercised in healing was continued beyond the time of the disciples. On what grounds such a belief should have been given up, or when, or by what authority the power of healing the sick by prayer has been revoked, we do not know. We know that most good people believe that this was one of the special gifts, intended only as a sign to establish the new religion and that it filled its mission in the time of the deciples. But, it is pertinent still to ask what is the authority for this belief? We do not believe such a doctrine is taught in the Bible, but we do believe the author of this new and interesting book is right in his views, because they harmonize in all important essentials with the scriptures on the subject as we have read them for years. In many particulars his detailed statements of different phases of this great study are clearer and better than we have seen or known before. The book has therefore helped us in the use of this wonderful power, and we are grateful for it. The author has done good service in this important field of labor and it is to be hoped, for the cause of truth and great need, his ready and forceful pen will not be long idle.

The Jones' Logarthmic Tables. In a recent number of THE MESSENGER a notice of Professor Jones' new book of Logarithmic Tables was given, setting out somewhat fully the merits of it and calling attention to its convenience of form and arrangement. Professor Jones has earnestly striven to free the tables of all errors and offered liberal reward to any one who would aid him in the work of determining and securing complete accuracy. The edition for 1890 is probably very nearly correct, if not entirely so. The book is 8vo in form, contains 72 pages in flexible cover, price 50 cents; to teachers 25 cents; for introduction 35 cents. Its large open pages, its clear type, and its strong, heavy paper make it an attractive and a durable hand-book for the computer's table.



Elias. Loomis